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INSTALLATION RESTORATION PROGRAM
PHASE II—CONFIRMATION/QUANTIFICATION
STAGE 2
VOLUME I

TYNDALL AIR FORCE BASE
FLORIDA

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
P.O. BOX ESE
GAINESVILLE, FLORIDA 32602-3052

AUGUST 1988

FINAL REPORT
AUGUST 1986 TO AUGUST 1988

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION IS UNLIMITED

Prepared for:
HEADQUARTERS TACTICAL AIR COMMAND
COMMAND SURGEON'S OFFICE (HQTAC/SGPB)
BIOENVIRONMENTAL ENGINEERING DIVISION
LANGLEY AIR FORCE BASE, VIRGINIA 23665

UNITED STATES AIR FORCE
OCCUPATIONAL & ENVIRONMENTAL HEALTH LABORATORY (USAFOEHL)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

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A Phase II-Stage 2 survey was conducted at Tyndall Air Force Base (AFB) to confirm and quantify the existence of potential contaminants at former disposal, storage, and fire training sites identified during Phase I and Phase II-Stage 1 studies. Nine sites were investigated including three disposal areas, three fuel storage areas, and three fire training areas.

Seventeen ground water monitor wells were installed in the surficial aquifer at the various sites investigated. A surface geophysical survey was conducted at one landfill area to determine the presence and areal extent of ground water contamination. Surface waters, ground waters, sediments, and soils were sampled and analyzed for various specific parameters including pH, specific conductance, total petroleum hydrocarbons, purgeable organics, base/neutral and acid extractable organics, dibromoethane, and priority pollutant metals. Eight of the nine zones were recommended for continued monitoring, and one zone was recommended for corrective action.

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PREFACE

The Installation Restoration Program Phase II Stage 2: Confirmation/Quantification, Tyndall Air Force Base, Florida, was prepared by Environmental Science and Engineering, Inc., Gainesville, Florida.

This report presents results of ground water and soil contamination assessments conducted at 9 sites on Tyndall Air Force Base: Ground water samples from 9 sites were analyzed for specific organic compounds and metals. In addition, surface water and sediment samples were collected and analyzed from two of the sites. The potential for an imminent human health hazard at each of the 9 sites was assessed based on analytical data, proximity of water supply wells, and local geohydrologic conditions.

This work was initiated in October 1986 and was completed in August 1988.

Lt. Dale Dietzel, Technical Services Division, USAF Occupational and Environmental Health Laboratory was the Technical Monitor.

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EXECUTIVE SUMMARY

The Phase II, Stage 2 Installation Restoration Program (IRP) Confirmation/Quantification study for Tyndall Air Force Base (AFB) investigated nine sites (Fig. 1), including three fuel storage areas, three fire training areas, and three landfill/disposal sites. One disposal site was located at the small arms repair facility and another at the Southeast Runway Extension Landfill. One site (Zone 2) was located near the town of Lynn Haven and is shown in Fig. 1.3-1.

A geophysical survey was conducted at the "6000" Area Landfill to locate buried items, delineate the boundaries of the burial site, and determine if any leachate plumes were evident in the shallow ground water.

Piezometers were installed at five sites where fewer than three functional monitor wells existed to serve as observation wells in which water levels in the surficial aquifer could be measured. Water-level data were used to determine ground water gradients and identify ground water flow directions in the surficial aquifer. Seventeen new monitor wells were installed to supplement existing monitor wells installed during the Phase II, Stage 1 investigation. Ground water, surface water, sediment, and soil samples were collected and analyzed as indicated in Table 1.

ZONE 2--LYNN HAVEN DEFENSE FUEL SUPPLY POINT (DFSP)

Potential contamination resulting from disposal of leaded fuel tank sludges was investigated at this site. The laboratory detection limits were well within the acceptable range specified by U.S. Environmental Protection Agency (EPA) Standard Operating Procedure. Low levels of total petroleum hydrocarbons at concentrations ranging from 0.090 to 0.78 milligrams per liter (mg/L) were detected in all but two wells at this zone. Trace levels of lead were also detected in three of the monitor wells, at levels considerably below the state and NPDWR MCLs of 0.050 mg/L. Trace levels of two volatile organic compounds

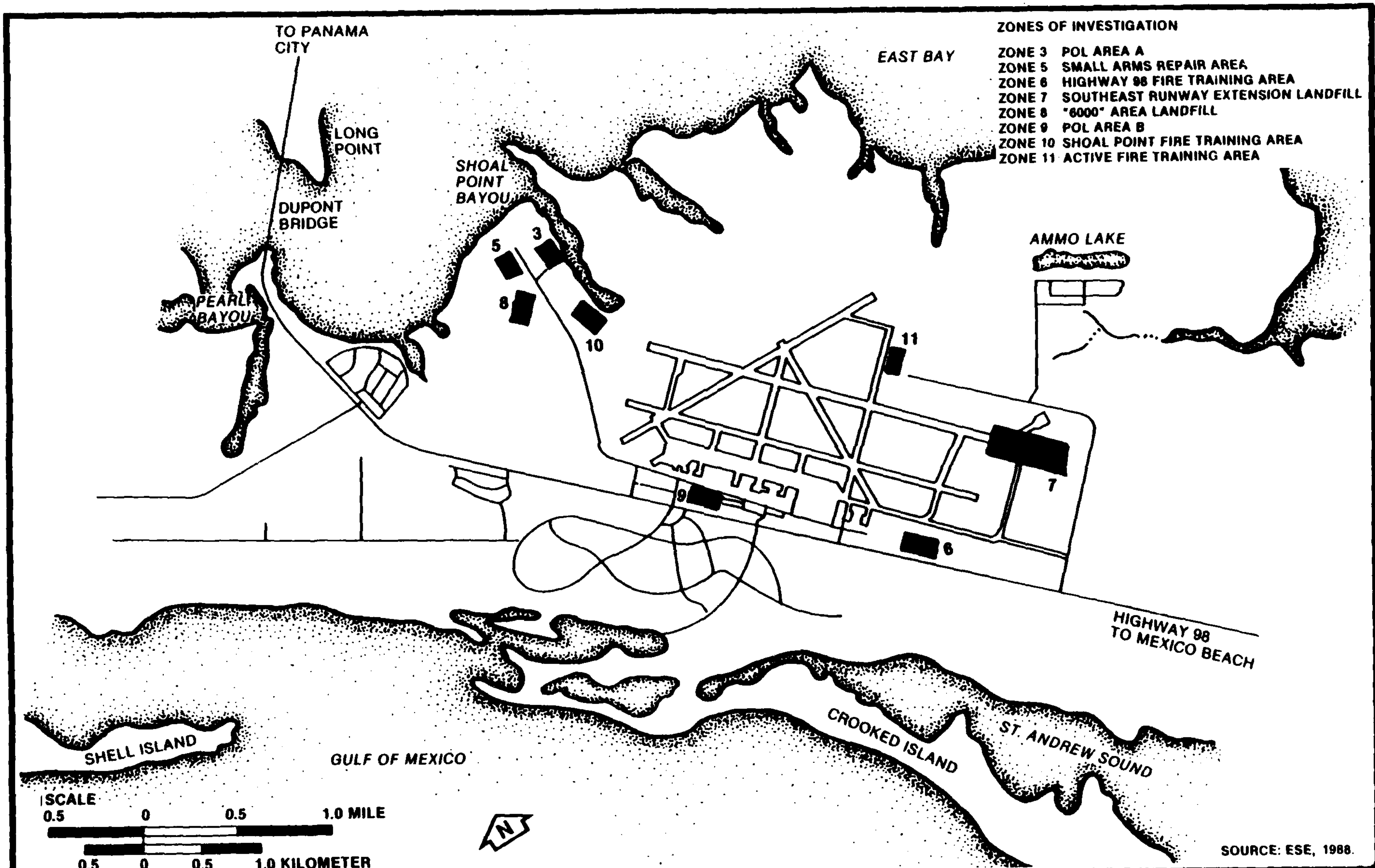

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Figure 1
LOCATION MAP OF ZONES INVESTIGATED AT TYNDALL AFB

INSTALLATION RESTORATION PROGRAM
Tyndall Air Force Base

Table 1. Tyndall AFB Phase II, Stage 2 Monitoring and Analysis

Site Description	Monitoring/Analysis Description
Zone 2--Lynn Haven DFSP	Install two additional downgradient monitor wells. Collect seven ground water, one surface water, and one sediment sample and analyze all samples for: Purgeable organics Petroleum hydrocarbons Lead
Zone 3--POL Area A	Install one upgradient and two downgradient monitor wells. Collect seven ground water samples and analyze for: Purgeable organics Ethylene dibromide (EDB) Petroleum hydrocarbons Lead
Zone 8--"6000" Area Landfill	Install two piezometers. Conduct geophysical surveys (electromagnetic conductivity and magnetometry) across the site. Install two downgradient monitor wells. Collect three ground water samples and analyze for: Purgeable organics Base/neutral and acid-extractable organics Priority pollutant metals
Zone 7--Southeast Runway Extension Burial Site	Collect four ground water samples (three monitor wells, one base well) and analyze for: Purgeable organics Base/neutral and acid-extractable organics Priority pollutant metals
Zone 5--Small Arms Repair Area	Collect three ground water samples and analyze for: Purgeable organics Acid-extractable organics Priority pollutant metals
Zone 6--Highway 98 Fire Training Area	Install two piezometers.

Table 1. Tyndall AFB Phase II, Stage 2 Monitoring and Analysis (Continued, Page 2 of 2)

Site Description	Monitoring/Analysis Description
Zone 6--Highway 98 Fire Training Area (Continued)	Install one upgradient and one downgradient monitor well. Collect five ground water samples and analyze for: Purgeable organics Acid-extractable organics Petroleum hydrocarbons Lead
Zone 9--POL Area B	Install one piezometer. Install one upgradient and one downgradient monitor well. Collect four ground water samples and analyze for: Purgeable organics EDB Petroleum hydrocarbons Lead
Zone 10--"Shell Bank" Fire Training Area	Install three piezometers. Install one upgradient and two downgradient monitor wells. Collect three ground water samples and analyze for: Purgeable organics Acid-extractable organics Petroleum hydrocarbons Lead
Zone 11--Active Fire Training Area	Install three piezometers. Install one upgradient and two downgradient monitor wells. Collect three soil samples and analyze for: Purgeable organics Petroleum hydrocarbons Lead Collect three ground water, two surface water, and two sediment samples and analyze for: Purgeable organics Acid-extractable organics Petroleum hydrocarbons Lead

Sources: Thiess et al., 1984.
ESE, 1988.

trichlorofluoromethane [0.10 microgram per liter (μg/L)] and methylene chloride (0.095 μg/L) were detected in ground water samples from the surficial aquifer at this site. A surface water sample from a drainage ditch leading from an oil/water separator at the petroleum, oils, and lubricants (POL) area to East Bay was found to contain detectable levels of benzene (0.54 μg/L) and toluene (0.80 μg/L). Total petroleum hydrocarbons at a concentration of 4.2 mg/L were also present in the surface water sample.

Detectable levels of lead [98 milligrams per kilogram (mg/kg)] and total petroleum hydrocarbons (35,000 mg/kg) were detected in a sediment sample from the drainage ditch leading from the oil/water separator.

ZONE 3--POL AREA A

Potential contamination resulting from the disposal of leaded fuel tank sludge was investigated at this site. Low levels of lead were detected in all but one well at Zone 3 at levels below the state and NPDWR MCL of 0.050 mg/L. Well T3-3 contained lead at a concentration of 0.17 mg/L, slightly exceeding the MCL of 0.05 mg/L. Total petroleum hydrocarbons were detected in two of the seven monitor wells at this zone at low concentrations ranging from 0.10 to 0.19 mg/L. Trace levels of six volatile organic compounds (bromodichloromethane, chloroform, chloromethane, methylene chloride, trichlorofluoromethane, and toluene) were also detected at Zone 3. Methylene chloride exceeded EPA ambient water quality criteria for the protection of human health of 0.19 μg/L. All other volatile organic compounds were below applicable state and EPA criteria.

ZONE 5--SMALL ARMS REPAIR AREA

Potential contamination resulting from the disposal of waste paints and solvents was investigated at this zone.

Ground water samples at Zone 5 contained trace levels of bromodichloromethane and chloroform, both below the state and NPDWR MCLs for total trihalomethanes (THMs) of 100 μg/L. Phenolic compounds were not present in any ground water samples from this site. Detectable levels of

9 priority pollutant metals were found in ground water samples from this zone, with concentrations of arsenic, and chromium exceeding state and NPDWR MCLs. All other metals detected at Zone 5 were below applicable state and EPA criteria.

ZONE 6--HIGHWAY 98 FIRE TRAINING AREA

Potential contamination associated with fire training activities and storage of waste POLs was investigated at this site. Total petroleum hydrocarbons and lead were detected in ground water samples from this site. All lead concentrations were below the state and NPDWR MCLs of 0.050 mg/L. Concentrations of total petroleum hydrocarbons ranged from 0.12 to 4.9 mg/L. Six volatile organic compounds including chlorinated solvents, benzene, and toluene were also detected and confirmed at Zone 6. All volatile organic compounds were below applicable state and EPA criteria, with the exception of benzene.

ZONE 7--SOUTHEAST RUNWAY EXTENSION BURIAL SITE

Potential contamination resulting from the disposal of used containers, drums, old batteries, and old parts was investigated at this site. Chlorinated solvents, phthalates, and priority pollutant metals were found in ground water samples from the surficial aquifer at Zone 7. Six priority pollutant metals were detected, with concentrations of arsenic slightly exceeding the state and NPDWR MCLs of 0.050 mg/L. Beryllium and thallium were also detected at levels exceeding the EPA ambient water quality criteria for the protection of human health. All other metal concentrations were below applicable state and EPA criteria. Base Well 11, located at the Alert Facility, downgradient of the suspected area of contamination at Zone 7, contained low levels of 1,1,1-trichloroethane, bis(2-ethylhexyl)phthalate, thallium, and zinc.

All organic compounds and metals detected in Base Well 11 were below applicable state and NPDWR MCLs and EPA ambient water quality criteria for the protection of human health with the exception of thallium. Base Well 11 is screened in the surficial aquifer at a depth of 110 to 115 feet (ft) and is used as a water source for the Alert Facility.

Bottled water is supplied for drinking purposes at the Alert Facility due to the high dissolved solids content and poor test quality of the well water.

ZONE 8--"6000" AREA LANDFILL

Potential contamination resulting from the disposal of old parts, batteries, and empty containers was investigated at this site. A surface geophysical survey conducted at this zone indicated the presence of buried metallic objects within the landfill boundary. Clear evidence of a contaminant plume associated with the landfill could not be established by the geophysical survey. Trace levels of five organic compounds [chloroform, chloromethane, trichlorofluoromethane, bis(2-ethylhexyl)phthalate, and di-n-octylphthalate] were detected at Zone 8. All organic compounds were present at concentrations below their respective state and NPDWR MCLs and EPA ambient water quality criteria for the protection of human health. Five priority pollutant metals were detected in ground water samples, with concentrations of arsenic slightly exceeding state and NPDWR MCLs of 0.050 mg/L. All other metal concentrations detected at Zone 8 were below state and NPDWR MCLs. Pesticides and PCBs were not detected at Zone 8.

ZONE 9--POL AREA B

Potential contamination resulting from the disposal of lead fuel tank sludge was investigated at this site. Low levels of total petroleum hydrocarbons were detected in three out of four monitor wells at Zone 9, with concentrations ranging from 0.17 to 6.1 mg/L. Trace levels of lead were detected in three monitor wells, below the state and NPDWR MCLs of 0.050 mg/L. Seven volatile organic compounds including chlorinated solvents, benzene, ethylbenzene, and toluene were also detected in ground water samples from Zone 9. Detectable levels of benzene (270 μg/L), ethylbenzene (140 μg/L), and toluene (140 μg/L) were detected in Well T9-4. All other volatile organic compounds at this site were below applicable state and NPDWR MCLs, and EPA ambient water quality criteria for the protection of human health. The concentration of benzene in Well T9-4 exceeded the state MCL of 1 μg/L and the NPDWR MCL of 5 μg/L.

Concentrations of benzene and other volatile organic compounds at this zone indicate the possibility of a leaking storage tank at this site.

ZONE 10--"SHELL BANK" FIRE TRAINING AREA

Potential contamination associated with fire training activities and storage of waste POL was investigated at this site. Lead was detected in only one monitor well at trace concentrations, below the state and NPDWR MCLs of 0.050 mg/L. Chloroethane, 1,1-dichloroethane, 1,1-dichloroethylene, and 1,2-dichloroethane were all detected at trace levels at Zone 10 below applicable state and EPA water quality criteria. Benzene, with a concentration of 34 μg/L in Well T10-2, exceeded the state MCLs of 1.0 μg/L, and the NPDWR MCLs of 5.0 μg/L.

ZONE 11--ACTIVE FIRE TRAINING AREA

Potential contaminants associated with fire training activities and storage of waste POL were investigated at this site. Trace levels of total petroleum hydrocarbons (0.12 mg/L) were detected in ground water samples from the surficial aquifer at this site. Lead (0.056 mg/L) was found to slightly exceed the state and NPDWR MCLs of 0.050 mg/L in monitor Well T11-1. Ground water samples also contained detectable levels of toluene and benzene. Benzene was detected at a concentration of 35 μg/L, exceeding both the state and NPDWR MCLs. Phenolic compounds were not detected at this site.

Surface water samples from Little Cedar Bayou, adjacent to the oil/water separator outfall at Zone 11 contained low levels of petroleum hydrocarbons (0.26 mg/L). Lead was not detected in the surface water samples. Surface water samples from Little Cedar Bayou contained trichloroethene at trace concentrations below applicable state and EPA criteria.

Soil borings were collected at three locations at Zone 11 where fuel spills had visibly impacted the surface vegetation and soil. Soil samples were found to contain levels of petroleum hydrocarbons (1,200 mg/kg), benzene (4.9 mg/kg), ethylbenzene (22 mg/kg), toluene

(40 mg/kg), xylene (146 mg/kg), and lead (1.8 mg/kg) near the aboveground fuel storage tank. Lead (2.9 mg/kg) and total petroleum hydrocarbons (260 mg/kg) were also found midway between the fire training pit and Little Cedar Bayou. The highest level of total petroleum hydrocarbons (27,000 mg/kg) was detected in a soil sample between the oil/water separator and Little Cedar Bayou.

Table 2 summarizes recommendations for all nine sites investigated at Tyndall AFB. Eight sites (Zones 2, 3, 5, 6, 7, 8, 10, and 11) were recommended for Category II, Additional Monitoring. One site (Zone 9) was recommended for Category III, Remedial Action. Zone 7 was recommended for remedial action if warranted by the results of the additional monitoring.

Table 2. Summary of Sampling and Analyses Recommendations for Tyndall AFB

Zone	Sampling Locations	Analyses: pH	Specific Conductance	Purgeables	Base/Neutral Extractables	Priority Pollutant Metals	Lead	Total Petroleum Hydrocarbons	Rationale for Recommendation
2 Lynn Haven DFSP	Existing Well LH2-4	X	X	X					The ground water sample from this well was found to contain low levels of volatile organics. Additional sampling is recommended to confirm the presence of these compounds.
	New Sediment Stations, SD2-2, SD2-3, SD2-4 located in North Bay adjacent to Zone 2					X	X	X	Sediments were found to contain elevated levels of petroleum hydrocarbons and lead. Additional sampling stations are needed to assess areal extent of contamination.
	Soil and ground water sample station at Bunker C			X		X			Potential for contamination not fully investigated.
3 POL Area A	Existing Wells T3-1 through T3-7	X	X	X		X	X	X	Conduct confirmatory sampling round to evaluate presence of specific contaminants.
	Base Supply Well 6A	X	X	X		X	X	X	Base Well 6A should be sampled prior to use as a precautionary measure due to its location at Zone 3
	New sediment and surface water stations SD3-1, SD3-2, and SD3-3 in Shoal Point Bayou and sludge burial area	X	X	X		X	X	X	Determine if contaminants detected in Well T3-3 are entering Shoal Point Bayou, and determine potential for contamination at the sludge burial area
5 Small Arms Repair Area	Existing Wells T5-1 through T5-3	X	X			X			Confirmatory round of sampling for priority pollutant metals.
	New Wells T5-4, T5-5, T5-6 located around the outside of existing wells	X	X			X			Determine areal extent of ground water contamination in surficial aquifer.

Table 2. Summary of Sampling and Analyses Recommendations for Tyndall AFB (Continued, Page 2 of 5)

Zone	Sampling Locations	Analyses: pH	Specific Conductance	Purgeables	Base/Neutral Extractables	Priority Pollutant Metals	Lead	Total Petroleum Hydrocarbons	Rationale for Recommendation
	Soil samples in area of contamination					X			Determine areal extent and concentration of source of metals contamination in soils.
	Test Base Well 5A					X			Determine if any contamination has migrated to the Floridan Aquifer.
6 Highway 98 Fire Training Area	Existing Wells T6-1 through T6-5	X	X	X		X		X	Conduct confirmatory round of sampling to confirm presence of compounds and metals previously detected.
	New Wells T6-6 and T6-7 located upgradient of T6-3	X	X	X		X	X	X	Determine upgradient extent of contaminant plume.
	Soil Gas Samples in area between T6-5 and T6-3 and Highway 98			X		X			Determine source of contamination in this area.
	Soil Samples from areas of contamination based on results of soil gas survey			X		X	X	X	Determine concentration and areal extent of contaminants in soil at this site.
7 Southeast Runway Extension Burial Site	Soil samples from area of suspected contamination			X	X	X			Define source of contaminants, if warranted, by additional ground water analyses.
	An additional well between source of contamination and Base Well 11	X	X	X	X	X			Determine extent of contaminant plume between source and the Base Well 11.
	Existing Wells T7-1 through T7-3 and Base Well 11	X	X	X	X	X			Confirm presence of contaminants in existing wells with a confirmatory round of sampling.

Table 2. Summary of Sampling and Analyses Recommendations for Tyndall AFB (Continued, Page 3 of 5)

Zone	Sampling Locations	Analyses: pH	Specific Conductance	Purgeables	Base/Neutral Extractables	Priority Pollutant Metals	Lead	Total Petroleum Hydrocarbons	Rationale for Recommendation
	Risk assessment								Evaluate threat to potential receptors if additional confirmation of contaminant migration to Base Well 11 is determined.
	Corrective measures, if warranted								Carry out remedial measures to decrease potential of human health hazard.
8 "6000" Area Landfill	Existing Wells T8-1, T8-3, and T8-4	X	X	X	X	X			Confirm levels of contaminants with a confirmatory round of sampling.
	Additional Well T8-5 downgradient of T8-4	X	X	X	X	X			Determine downgradient extent of ground water contamination at site.
	Sample areas with stressed vegetation	X	X	X	X	X			Potential for contamination not fully investigated
9 POL Area B	Conduct tank tightness tests on all underground storage tanks in area								Determine if a tank is leaking.
	Additional Wells T9-5 and T9-6	X	X	X		X	X	X	Determine upgradient and downgradient extent of contamination.
	Additional Well T9-7 located near T9-4 at a depth of 50 to 100 ft	X	X	X		X	X	X	Determine vertical extent of contamination.
	Existing Wells T9-1 through T9-4	X	X	X		X	X	X	Conduct confirmatory round of sampling to verify ground water contaminant levels

Table 2. Summary of Sampling and Analyses Recommendations for Tyndall AFB (Continued, Page 4 of 5)

Zone	Sampling Locations	Analyses							Rationale for Recommendation
		pH	Specific Conductance	Purgeables	Base/Neutral Extractables	Priority Pollutant Metals	Lead	Total Petroleum Hydrocarbons	
	Soil gas samples in area of contamination			X					Determine areal extent of contamination by volatile organic contaminants.
	Aquifer testing								Determine fate and transport of pollutants.
	Risk assessment								Evaluate threat to potential receptors.
	Corrective measures								Carry out remedial measures to decrease potential of human health hazard.
10 "Shell Bank" Fire Training Area	Existing Well T10-2	X	X	X					Confirm presence of volatile organics.
	Surface water/sediment samples SW-1 and SD-1 in Shoal Point Bayou	X	X	X				X	Evaluate migration of contaminated ground water into Shoal Point Bayou.
	Soil gas samples in area of contamination			X					Determine areal extent of volatile organic contaminants in soil.
	Soil samples in area of contamination			X			X	X	Determine concentrations of contaminants in soils.
	Additional wells installed based on results of soil gas and soil sampling results	X	X	X			X	X	Determine the areal extent of contaminants in ground water in the surficial aquifer.

Table 2. Summary of Sampling and Analyses Recommendations for Tyndall AFB (Continued, Page 5 of 5)

		Analyses							
Zone	Sampling Locations	pH	Specific Conductance	Purgeables	Base/Neutral Extractables	Priority Pollutant Metals	Lead	Total Petroleum Hydrocarbons	Rationale for Recommendation
11 Active Fire Training Area	Existing Wells T11-1 through T11-3	X	X	X		X	X	X	Conduct confirmatory round of sampling to verify presence of contaminants.
	Additional Wells T11-4 downgradient of fuel tank, T11-5 downgradient of oil/water separator	X	X	X		X	X	X	Identify areal extent of ground water contamination.
	Soil gas in areas of contamination			X					Identify area of contamination by volatile organic contaminants.
	Soil sampling in areas of contamination			X		X	X	X	Determine concentrations of contaminants in soil.
	Fuel storage tank and oil/water separator								Take measures to prevent further release of POL related contaminants at this site.

Source: ESE, 1988.

1.0 INTRODUCTION

1.1 INSTALLATION RESTORATION PROGRAM BACKGROUND

This report describes the Phase II, Stage 2 Contamination Assessment (CA) for Tyndall Air Force Base (AFB), Florida. Phase II of the Department of Defense (DOD) Installation Restoration Program (IRP) pertains to the confirmation and quantification of suspected contamination at former hazardous materials/waste storage or disposal sites.

Due to the nature of activities carried out by the U.S. Air Force (USAF), numerous toxic and hazardous chemicals have been used as part of routine operations. Federal, state, and local governments have developed strict regulations requiring that disposers identify the locations and contents of disposal sites and take action to eliminate the hazards in an environmentally responsible manner. To assure compliance with hazardous waste regulations, DOD developed the IRP. The current DOD IRP policy is contained in Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, dated Dec. 11, 1981, and implemented by a USAF message dated Jan. 21, 1982. DEQPPM 81-5 reissued and amplified all previous directives and memoranda on the IRP. DOD policy is to identify and fully evaluate suspected problems associated with past hazardous contamination and to control hazards to health and welfare that resulted from these past operations. The IRP is the basis for response actions on USAF installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.

The objectives of the IRP are to:

1. Identify and evaluate suspected problems at past hazardous material disposal sites;
2. Assess the migration of hazardous contaminants;
3. Assess resulting hazards to health, welfare, and environment; and
4. Consider feasible remedial actions.

The four phases of the IRP include:

Phase I--Initial Assessment/Records Search,
Phase II--Confirmation and Quantification,
Phase III--Technology Base Development, and
Phase IV--Operations/Remedial Actions.

Phase I, Initial Assessment/Records Search, is designed to identify sites where hazardous-waste may have been disposed. The Phase I report, completed for Tyndall AFB in December 1981 (Hatch et al., 1981), reviews the history of base operations and waste disposal practices, the geological and hydrogeological conditions which may affect contaminant migration, and the ecological setting. All hazardous waste disposal sites identified in the Phase I report are ranked on the basis of a standard evaluation system [Hazardous Assessment Rating Methodology (HARM)], which is applied to all installation records searches.

Phase II of the IRP addresses the confirmation and quantification of the extent and magnitude of contaminant migration from sites identified in Phase I. Phase II, Stage 1 consists of a preliminary survey to confirm or rule out the presence and/or migration of contaminants. This stage consists of field surveys, environmental sampling and analysis, data reduction and interpretation, and development of recommendations for remedial action and/or additional monitoring. Phase II, Stage 2 provides additional monitoring data upon which design of mitigative actions is based. Phase III, Technology Base Development, consists of research and development of new technology for remedial actions. Phase IV, Operations/Remedial Action, involves construction, operation, and maintenance of the corrective action option designed under Phase III.

Water and Air Research, Inc. (WAR) conducted the Phase II, Stage 1 survey for Tyndall AFB to provide a preliminary identification of potential contamination at 11 sites at various locations across the base and at Lynn Haven Defense Fuels Supply Point (DFSP) in Lynn Haven, Florida. Based on the findings of the Phase II, Stage 1 report (Thiess et al., 1984), Environmental Science and Engineering, Inc. (ESE) conducted the Phase II, Stage 2 CA for Tyndall AFB to confirm the presence/absence of specific contaminants; quantify their concentrations in ground water, surface water, soil, and sediments; and define the extent of their migration at nine sites on Tyndall AFB and Lynn Haven DFSP.

1.2 OBJECTIVE AND SCOPE

Phase II of the IRP addresses the confirmation and quantification of the extent and magnitude of contaminant migration from sites identified in Phase I. Phase II, Stage 1 consisted of a preliminary survey to confirm or rule out the presence and/or migration of contaminants. The Phase II, Stage 2 investigation at Tyndall AFB was conducted in an effort to accomplish the following:

1. Determine the magnitude of contamination and the potential for contaminant migration in the various environmental media.
2. Identify potential environmental consequences and health risks of migrating pollutants based on state or Federal standards for those contaminants.
3. Categorize each site with respect to the need for future monitoring as follows:

   Category I: No further action is required,

   Category II: Site requires additional investigation to quantify or further assess the extent of current or future contamination, and

   Category III: Site requires remedial actions (for the IRP Phase III or IV actions).

For those sites requiring remedial action, a list of candidate remedial action alternatives that can attain applicable environmental standards is provided.

To obtain the data necessary to accomplish these tasks, an extensive field investigation was undertaken. The field survey included installation of piezometers and monitor wells; surface geophysical surveying; and sampling of ground water, surface water, sediments, and soils. Samples were shipped to ESE's state-certified laboratory in Gainesville, Florida, for analysis. The results of these analyses were used to provide the basis for the recommendations made for each of the nine zones on Tyndall AFB and Lynn Haven DFSP identified during previous investigations.

1.3 INSTALLATION DESCRIPTION AND HISTORY

1.3.1 SITE DESCRIPTION

Tyndall AFB is located in Bay County, Florida, about 12 miles southeast of Panama City, as shown in Fig. 1.3-1. The base is situated on a narrow northwest-southeast trending peninsula that extends about 18 miles along the Gulf of Mexico from the resort community of Mexico Beach southeast of the base to the main shipping channel in St. Andrew Bay. The installation covers approximately 28,000 acres, and is bordered by the Gulf of Mexico and St. Andrew Sound to the southwest, St. Andrew Bay to the north and west, and East Bay to the northeast. Tyndall AFB also supports various activities offbase, including Lynn Haven DFSP, which was included in the Phase II, Stage 2 survey.

1.3.2 FACILITY HISTORY

[NOTE: Information in this section is excerpted from the Tyndall AFB Phase II, Stage 1 report (Thiess et al., 1984)]

Tyndall AFB was activated in 1941 at the outset of World War II (WWII) and became the center of the Army Air Corp's first flexible gunnery school. When WWII ended in 1945, Tyndall Field briefly operated on a

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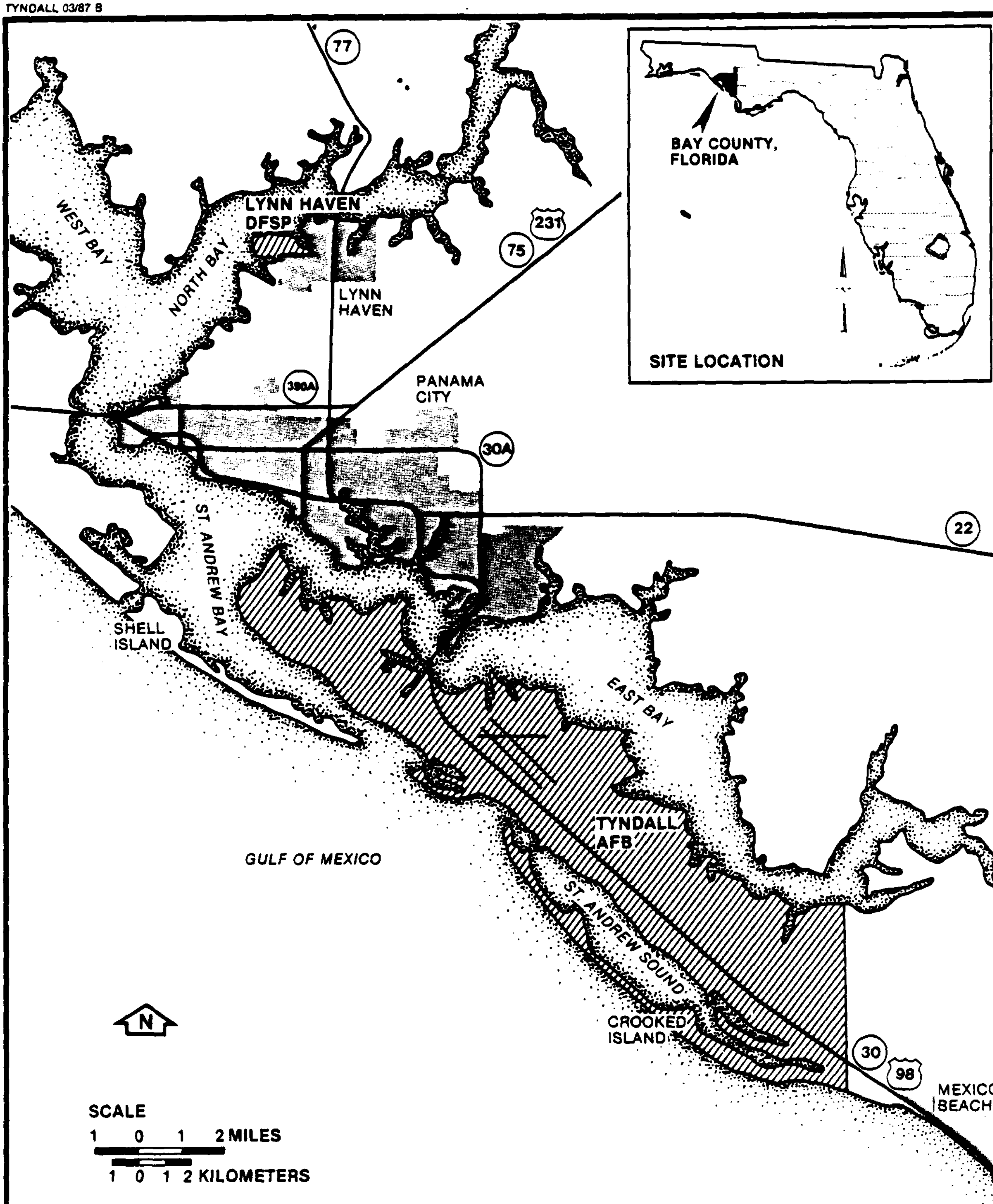

SOURCE: ESE, 1988.

Figure 1.3-1
LOCATION MAP OF TYNDALL AFB AND LYNN HAVEN DFSP

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standby status. In May 1946, it became the home of the Air University's Air Tactical School, training junior officers in the responsibilities of command at squadron level. The name of the installation was changed to Tyndall Air Force Base in 1947 when the Air Force became a separate branch of the military service. In 1950, the base was transferred to the Air Training Command and became responsible for training all-weather jet interceptor pilots (F-86D) and aircraft controllers. The aircraft controller school remains an important part of activities at the base, training hundreds of personnel to operate radar scopes at aircraft control and warning stations around the world.

The base was transferred from the Air Training Command to the Air Defense Command in July 1957, when the F-86D interceptor school was transferred to Moody AFB, Georgia. At that time, Tyndall AFB's mission shifted to that of a weapons center. Its mission included four major areas:

1. Weapons training and system evaluation;
2. Testing of methods, tactics, techniques, and equipment;
3. Tactical air defense; and
4. Administering, equipping, training, and preparing subordinate units to accomplish their missions, in addition to providing support for all attached units in accordance with established Air Defense Command policies.

Tyndall's role as a weapons center was broadened in 1962 with the assignment of a new mission for aircrew transition training for F-101 and F-106 pilots. To fulfill this new mission, the 4756th Air Defense Wing was activated. This was the result of a new Air Defense Command training mission, which gave the command the responsibility of providing combat training for its own interceptor aircrews, a task previously accomplished by the Air Training Command.

The USAF Air Defense Weapons Center was activated on January 1, 1968, to provide a single area within DOD for the centralization of operational and technical expertise on air defense matters.

A new dimension to air defense weapons training was added to the weapons center's program on July 15, 1974, when the 62nd Fighter Interceptor Training Squadron/USAF Interceptor Weapons School conducted its first F-4 Air Defense Employment Course. This training was part of Project Worldwide Air Defense Enhancement, a program designed to significantly improve the air defense capabilities of aircrews assigned to the Tactical Air Command (TAC), Alaskan Air Command, Air Forces Iceland, Pacific Air Force, and USAF-Europe.

On February 7, 1975, the USAF Air Defense Weapons Center assumed responsibility for a program designed to convert surplus F-102 aircraft into pilotless targets or "drones" that would accurately and economically simulate the fighter aircraft threat. A program is currently underway utilizing the F-100 fighter as an unmanned target system.

The USAF Air Defense Weapons Center and Tyndall AFB were made a part of TAC in October 1979. During that reorganization, TAC assumed the air defense responsibilities and added a Deputy Chief of Staff for Air Defense to command the newly acquired forces. On July 1, 1981, the 325th Fighter Weapons Wing was established under the center.

1.4 SUMMARY OF PREVIOUS STUDIES

To execute Phase I of the IRP, CH_2M Hill Southeast, Inc. was retained by the Air Force Engineering and Services Center (AFESC) to conduct the Tyndall AFB Records Search. This records search was completed in December 1981 (Hatch et al., 1981). The records search included a detailed review of pertinent installation records, contacts with 13 Government agencies for documents relevant to the records search effort, and an onsite base visit conducted by CH_2M Hill personnel. Activities conducted during the onsite base visit included interviews with 35 past and current base employees, ground tours of base facilities, and a helicopter overflight to identify past disposal areas. Installations

addressed in the records search included Tyndall AFB, Carrabelle Missile Tracking Annex, St. George Island Aircraft Control Maneuvering Instrumentation (ACMI) Tower, Apalachicola Radio Relay Annex, Springfield Railroad Siding Annex, Cove Gardens Military Family Housing Satellite, Bay County Wastewater Treatment Lagoon, and Lynn Haven DFSP.

The records search resulted in the identification of 17 sites at Tyndall AFB with a potential for contaminant migration. In addition, the Lynn Haven DFSP was also identified as a site with a potential for contaminant migration. No potential contamination sites were identified at the Carrabelle Missile Tracking Annex, St. George Island ACMI Tower, Apalachicola Radio Relay Annex, Springfield Railroad Siding Annex, Cove Gardens, Military Family Housing Satellite, or Bay County Wastewater Treatment Lagoon.

The 18 sites were evaluated using a system for rating the hazard potential of waste disposal facilities. The USAF site evaluation system consists of rating factors that are divided into four categories: receptors, waste characteristics, pathways, and waste management practices. Based on this assessment methodology, the sites were prioritized for subsequent field work to be conducted under Phase II, Stage 1 of the IRP. WAR was retained by USAF OEHL to conduct Phase II, Stage 1 of the IRP for Tyndall AFB. This portion of the Phase II investigations was completed in August 1984 (Thiess et al., 1984). The survey included field work at 9 of the original 18 sites identified during the Phase I records search. In addition, two sites were discovered subsequent to the Phase I investigation and incorporated into the Phase II, Stage 1 survey. The sites investigated in the Phase II, Stage 1 study included five former landfill sites, four fuel storage areas, and two fire training areas.

During the Phase II, Stage 1 field effort, shallow ground water monitoring wells were installed either downgradient from or encircling 10 of the sites. Four backhoe pits were excavated at the remaining site. Shallow ground water from monitor wells, backhoe pits, and potable water wells; surface water; and sediments were sampled and analyzed. A summary of the Phase II, Stage 1 site descriptions, sample locations, and sample analyses is presented in Table 1.4-1. Most of these analyses were screening tests [pH, specific conductance, dissolved organic carbon (DOC), total organic halogens (TOX), total phenolics, and oil and grease], which are nonspecific indicators of contamination. Samples were analyzed for specific constituents [cadmium, chromium, iron, nickel, lead, zinc, dichlorodiphenyldichloroethane (DDT), and purgeable organics] where prior information indicated they may be present. Results of TOX screening analyses were positive at all but one sampling location. It was suspected that inorganic chlorides in the shallow ground water, present due to the proximity to saline waters, created a positive interference in the TOX analyses. At all stations analyzed for total phenolics, results were positive at levels less than 20 micrograms per liter (µg/L). Based on these analytical results, it was recommended that additional testing be conducted to verify the presence of positive chloride interference and/or organic halogen contamination, and to identify the presence of specific phenolic compounds. The analysis of specific phenolic compounds was recommended to determine whether the positive results obtained from Phase II, Stage 1 analyses were due to naturally occurring phenolic compounds or resulted from man-made contamination at the sites investigated. Installation of a single well near a former leaking gasoline tank at Zone 4 showed no sign of gross fuel contamination. Based on these results, Zone 4 was not included in the Phase II, Stage 2 survey. Sites 6 and 7 from the records search (Zone 1--main base landfill--of the Phase II, Stage 1 confirmation study) were selected for IRP Phase IV remedial action implementation and were not included in the Phase II, Stage 2 study.

Table 1.4-1. Summary of Sampling and Analyses for Tyndall AFB Phase II, Stage 1 Survey

Zone No.	Site Description	Sample Location(s)	Sample Analyses
1†	Main Base Landfill	Six monitor wells, one existing sewage sprayfield well, and four surface water samples from drainage ditch.	GWCI*, total phenolics, cadmium, chromium, iron, lead, nickel, and zinc.
		Three sediment samples from drainage ditch.	TOX, cadmium, chromium, iron, lead, nickel, zinc, and DDT.
2	Lynn Haven Defense Fuels Supply Point	Seven monitor wells.	GWCI*, lead, oil and grease, presence of visible fuel layer.
3	POL Area A	Four monitor wells.	GWCI*, lead, and oil and grease.
		One potable well.	pH, specific conductance, and purgeable organics.
4	AAFES Service Station	One monitor well.	Presence of visible fuel layer.
5	Small Arms Repair Area	Three monitor wells.	GWCI*, chromium, and lead.
6	Highway 98 Fire Training Area	Three monitor wells.	pH, specific conductance, DOC, total phenolics, lead, and purgeable organics.
7	Southeast Runway Extension Burial Site	Three monitor wells, one potable water well at adjacent Alert Facility.	pH, specific conductance, DOC, total phenolics, and lead.
8	"6000" Area Landfill	Two monitor wells.	GWCI*, total phenolics, chromium, lead, and zinc.
9	POL Area B	Two monitor wells.	GWCI* and lead.
10	"Shell Bank" Fire Training Area	Ground water samples from four backhoe pits.	GWCI*, total phenolics, and lead.

Notes: POL = petroleum, oils, and lubricants.
AAFES = Army and Air Force Exchange Service.
*GWCI = Ground water contamination indicators: pH, specific conductance, DOC, and TOX.
†Zone 1, the Main Base Landfill, actually represents two separate sites discovered during the Phase I Records Search.

Source: ESE, 1988.

Two types of monitoring wells were installed during the Phase II, Stage 1 field effort. Permanent wells were backfilled with sand auger cuttings to approximately 4.5 ft below the ground surface. A bentonite seal approximately 1-ft thick was placed on top of the sand. The remainder of the annular space was filled with sand-cement grout. A steel protective casing was placed around all permanent monitor wells. Temporary monitor wells were backfilled with sand auger cuttings to approximately 1 ft below ground level. The remainder of the annular space was filled with bentonite. No protective casings were placed around the temporary monitor wells.

1.5 DESCRIPTION OF SITES

The total number of zones investigated at Tyndall AFB during this survey was eight (Fig. 1.5-1), with the Lynn Haven DFSP constituting the ninth zone of investigation. Site characteristics of the nine zones investigated during the Phase II, Stage 2 study are summarized in Table 1.5-1.

1.5.1 ZONE 2--LYNN HAVEN DEFENSE FUEL SUPPLY POINT

Lynn Haven DFSP is located on 203.44 acres next to North Bay (Fig. 1.5-2). This facility has been used as a bulk fuels storage and dispensing terminal since 1943. Although the property is owned by Tyndall AFB, the facility was acquired by the Defense Fuel Supply Center in 1973 and is operated by a private contractor. Originally, the facility was operated by the U.S. Navy for storage of Bunker C fuel. Fuel was unloaded from tankers moored at four docks at the north end of the site and stored in 10 steel tanks still present at the facility. Fuel was then transferred to railroad tank cars for shipment throughout Florida and the southeast. A railcar maintenance facility was located in the southeast corner of the site, but was demolished in the early 1950s; only the floor slab remains.

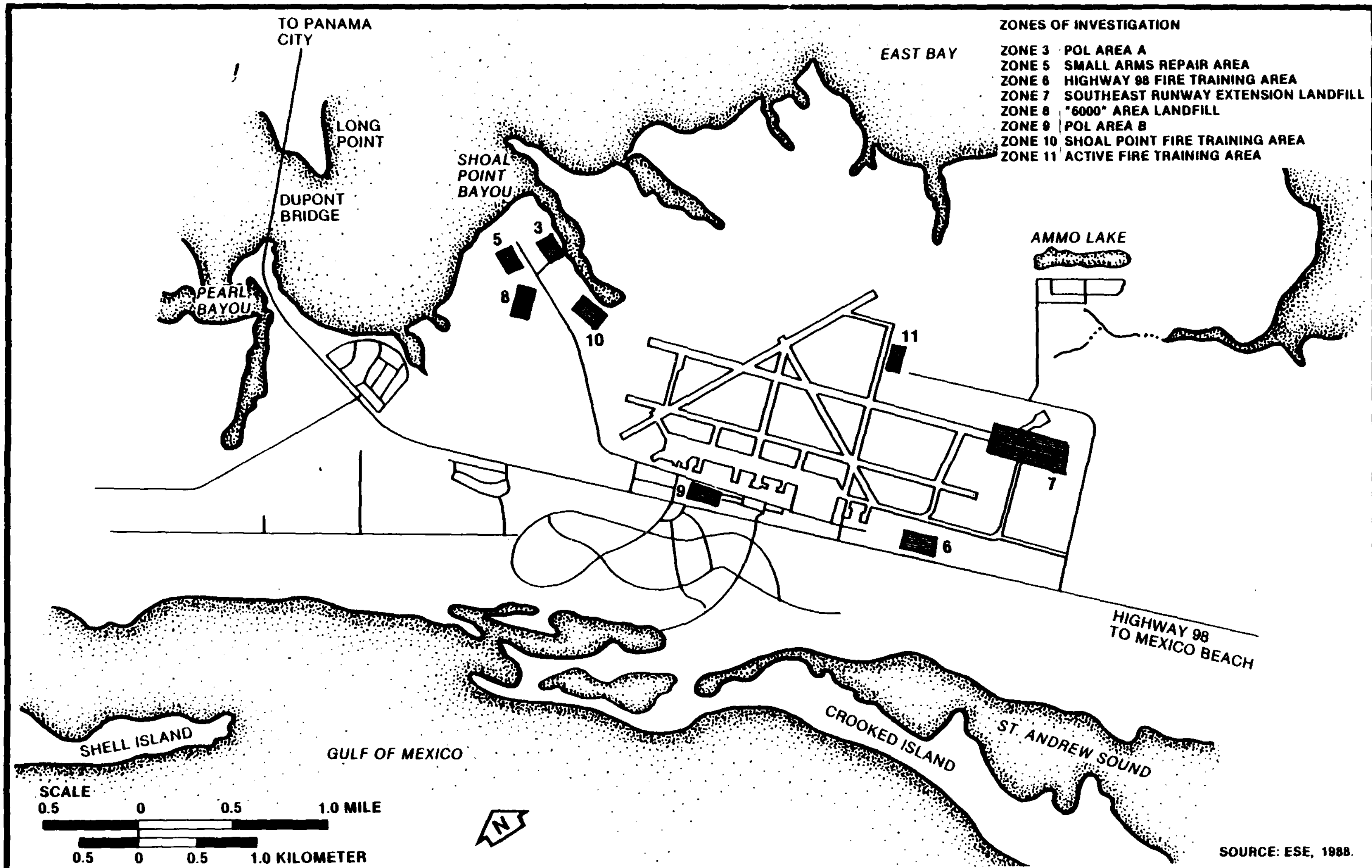

Figure 1.5-1
LOCATION MAP OF ZONES INVESTIGATED AT TYNDALL AFB

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Table 1.5-1. Site Characteristics of Zones Investigated During the Phase II, Stage 2 Investigations

Phase I Records Search Site No.	Phase II Stage 2 Zone No.	Site Description	Period of Usage	Nearest Drinking Water Well (ft)	Nearest Surface Water Body (ft)	Depth to Ground Water (ft)	Phase I Evidence/Quantity of Hazardous Wastes	Suspected Hazardous Waste Types
18	2	Lynn Haven DFSP	1943 to present	2,000	<500	2 to 10	Suspected/moderate	Sludge containing lead; Bunker C
14	3	POL Area A	1943 to present	<500	<500	0 to 5	Known/small	Sludge containing lead
1*	5	Small Arms Repair Area	1965 to 1972†	500	1,000	5 to 10	Suspected/moderate	Waste paints and solvents
17	6	Highway 98 Fire Training Area	1952 to 1968	2,800	3,000	5 to 10	None	Residue from burning of POL waste
4	7	Southeast Runway Extension Burial Site	1945 to 1965	<500	5,000	2 to 10	Suspected/small	Batteries, old parts, and containers
5	8	"6000" Area Landfill	1945 to 1965	<500	1,500	5 to 10	Suspected/small	Batteries, old parts, and containers
15	9	POL Area B	1943 to present	850	5,500	5 to 10	Suspected/small	Sludge containing lead
16	10	"Shell Bank" Fire Training Area	1943 to 1952 1968 to 1980	1,200	<500	2 to 10	None	Burning of POL waste
	11	Active Fire Training Area	1981 to present	4,000	<500	2 to 10	None	Burning of POL waste

*These sites were discovered subsequent to the Phase I records search; site designations were made in Phase IIa presurvey.
†Site may have been used prior to this period, although this could not be verified in interviews with base personnel.

Source: Hatch et al., 1981 (with updates).

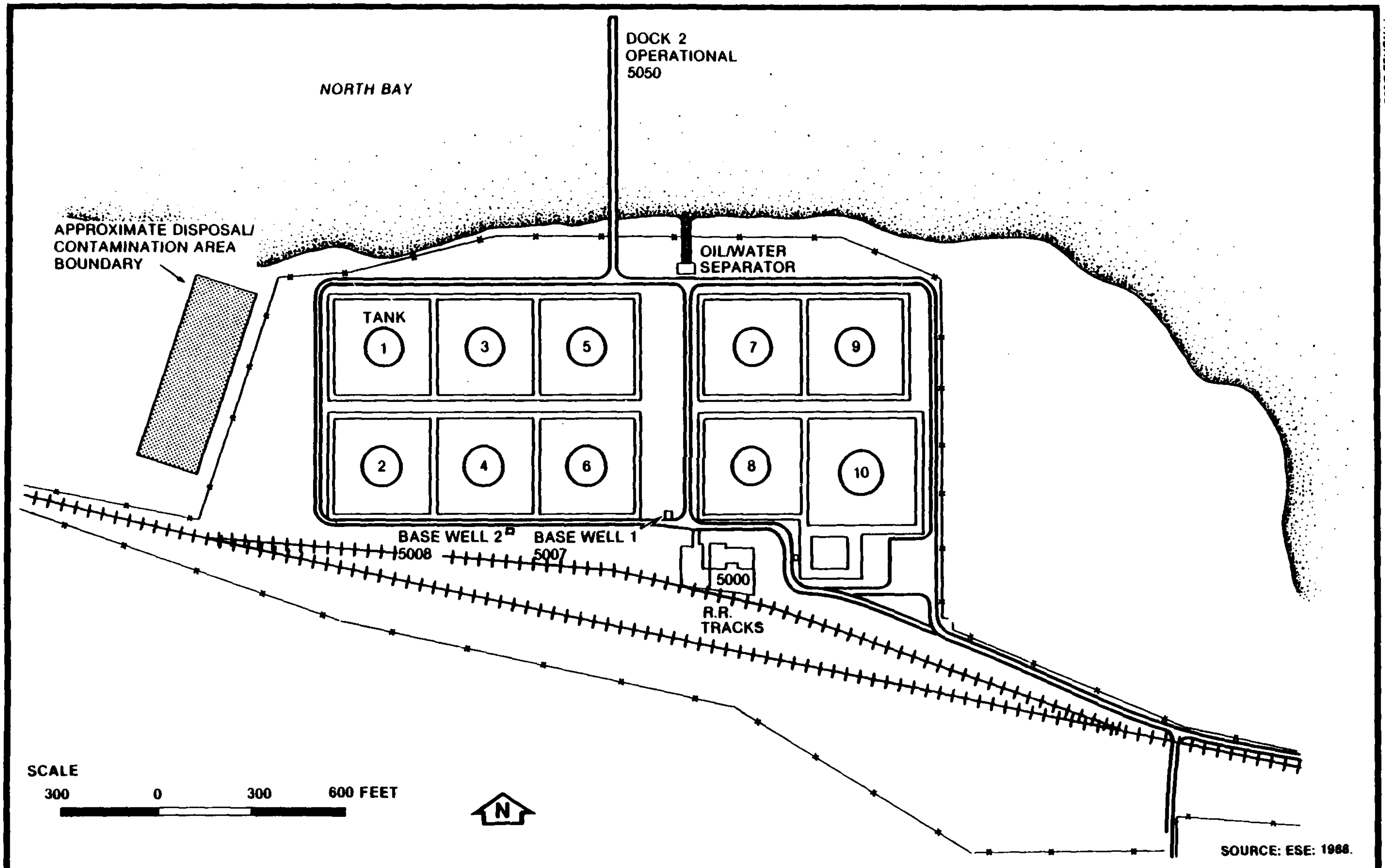

Figure 1.5-2
SITE MAP FOR ZONE 2 — LYNN HAVEN DFSP

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A drum loading station was originally present south of the railcar loading area and was used for loading drums filled with Bunker C fuel onto trucks for shipment. Steam, which was generated at that time for increasing the fluidity of Bunker C fuel, was also used for cleaning waste drums. The steam-cleaned oil was routinely dumped on the ground behind the drum loading station (Hatch et al., 1981).

In the early 1950s, Bunker C fuel was phased out of use. During the Phase I study, one of the interviewees reported that when Bunker C fuel became obsolete, fuel remaining in the bulk storage tanks was pumped out on the ground outside the west gate. Moderate quantities may have been disposed of in this way. The Phase I contractor conducted a ground tour of the facility, during which a thin layer of black, weathered sludge was observed in shallow pits in that area. A few abandoned drums and used dual-filter cartridges, among other trash, were also noted.

Since the 1950s, aviation gasoline (AVGAS), JP-4, and JP-5 have been the primary fuels stored at the facility. Prior to 1969, it was common practice to bury tank sludges within diked areas surrounding the storage tanks. Bottoms of the dike areas are extremely permeable, consisting of a sand base with a gravel cover. Locations and quantities of buried material were not recorded, and the wastes were not characterized. Some of the sludge was from leaded fuel. Leachate migration reportedly has not been observed or monitored, and most of the buried material is believed to have been removed during regrading and resurfacing of the terminal grounds.

Reports of minor spills have been common. Periodically, tanks are overtopped, spilling approximately 5,000 gal every 1 or 2 years. Minor spills also have occurred at the existing truck loading station and the railcar loading area. Measures to mitigate the effects of spills were undertaken in the late 1970s. An underdrain field was installed in 1980

beneath the railcar loading area as a spill mitigation measure. The underdrains, which discharge to a series of oil/water separators, have collected Bunker C fuel from ground water underlying the railcar loading area.

The facility currently operates six oil/water separators and has a National Pollutant Discharge Elimination System (NPDES) permit for six stormwater discharges to North Bay. These discharges are routinely sampled by the contractor operating the facility and analyzed for oil and grease, suspended solids, biochemical oxygen demand (BOD), pH, lead, and chromium. Limits for these parameters established by the NPDES permit have not been exceeded, with the exception of one oil and grease value of 6.1 milligrams per liter (mg/L) reported for January 1983. A resampling to confirm this value indicated oil and grease below the detection limit of 1 mg/L.

During Phase II, Stage 1 investigations, lead and oil and grease were not detectable at any Zone 2 wells. TOX and DOC were positive at most wells, although no visible fuel layers were detected at any wells.

1.5.2 ZONE 3--PETROLEUM, OILS, AND LUBRICANTS (POL) AREA A

The Zone 3 POL Area is located at the tank farm near the Shoal Point Bayou barge unloading facilities (Fig. 1.5-3). Since 1943, small quantities of residues from tank sludge removal operations have been routinely disposed into shallow trenches at this site. This procedure was considered to be an acceptable disposal method. Prior to 1974, however, AVGAS was commonly stored at the POL Area A tank farm, and residue from cleaning AVGAS storage tanks would have contained lead. In some instances, leaded tank bottoms from sludge removal operations are considered to be RCRA hazardous wastes (EPA Hazardous Waste No. K052).

Previous analyses at the site indicate the presence of a variety of organic compounds. Lead was detected in one ground water sample at a concentration of 0.034 mg/L.

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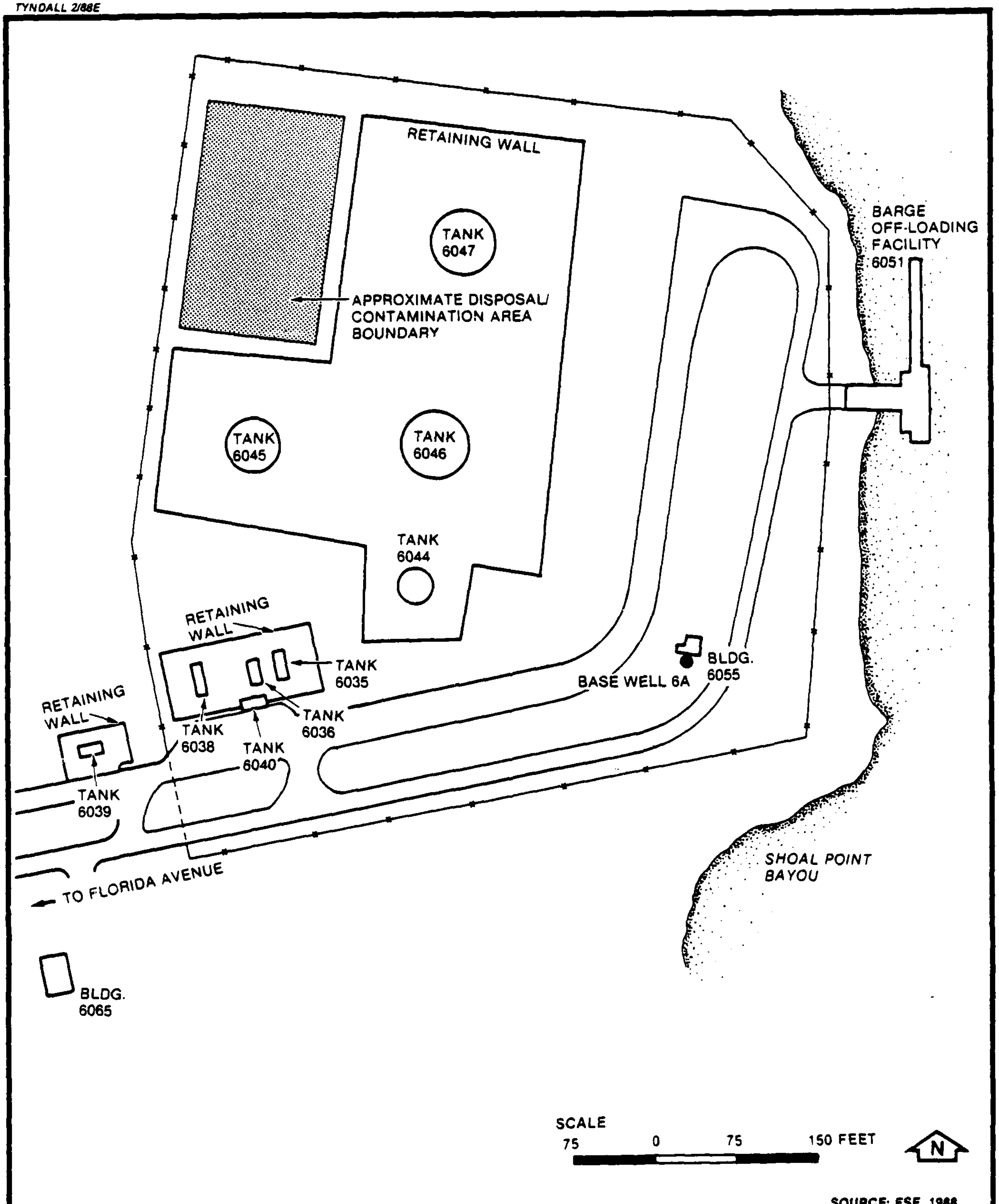

Figure 1.5-3
SITE MAP FOR ZONE 3—
POL AREA A

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1.5.3 ZONE 5--SMALL ARMS REPAIR AREA

Zone 5, the Small Arms Repair Area, is located in an open field in the "6000" area (Fig. 1.5-4). This site was discovered in conversations with base personnel subsequent to the Phase I records search. Significant amounts of waste paints and solvents were reported to have been disposed into an open pit. Base personnel indicated that the site was used between 1965 and 1972, although some usage may have occurred prior to that period.

Chromium and lead were not detected at any of the Zone 5 wells during the Phase II, Stage 1 studies. DOC and TOX indicators were positive in most samples.

Subsequent research into the types of processes used in the Small Arms Repair Area (blueing and parkerizing) has revealed the potential for selenium contamination at the site. Parkerizing is a process used by the military to keep weapons from rusting (as explained during the site survey by a Tyndall AFB employee).

1.5.4 ZONE 6--HIGHWAY 98 FIRE TRAINING AREA

Zone 6, referred to as the Highway 98 fire training area, was used from 1952 to 1968, and was located between the power check pads (Facility 84) and U.S. Highway 98 (Fig. 1.5-5). Zone 6 is also referred to as Site D, Drum Disposal Area, in the Phase II, Stage 1 presurvey. It was reported by one of the interviewees that 300 empty drums were crushed and buried approximately 300 ft east of this site in 1968. Standard procedure was to transport all empty drums to the Defense Property Disposal Office (DPDO) for salvage.

Zone 6 was one of the main repositories for POL waste from industrial operations at Tyndall AFB in the past. POL waste was transported to Zone 6 and deposited in two 20,000-gal storage tanks. The POL waste was then sold to contractors or used in fire-training exercises. The two 20,000-gal POL waste storage tanks were excavated and relocated in 1968. Standard procedure for the fire-training exercises was to pour POL waste

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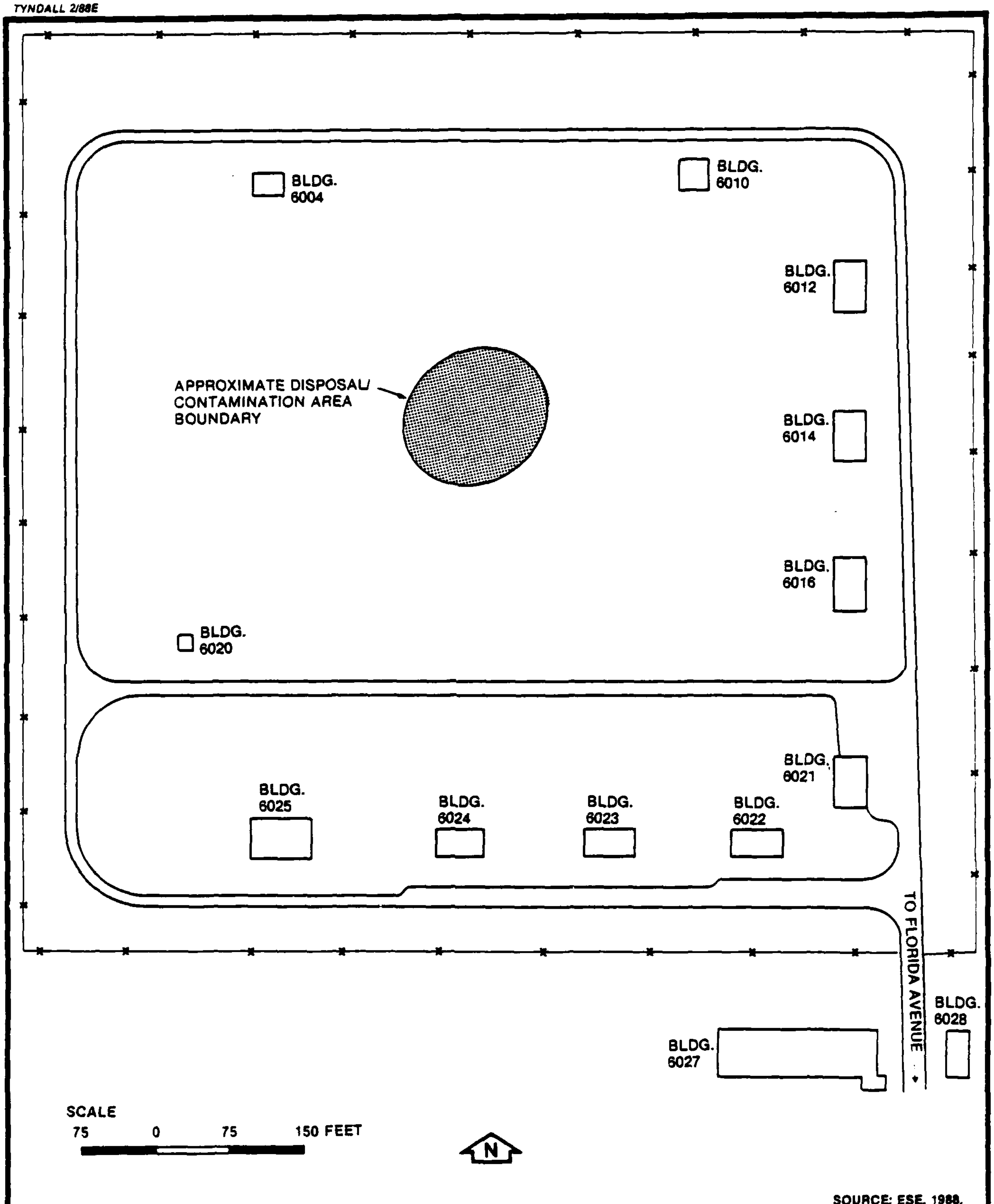

SOURCE: ESE, 1988.

Figure 1.5-4
SITE MAP FOR ZONE 5 — SMALL ARMS REPAIR AREA

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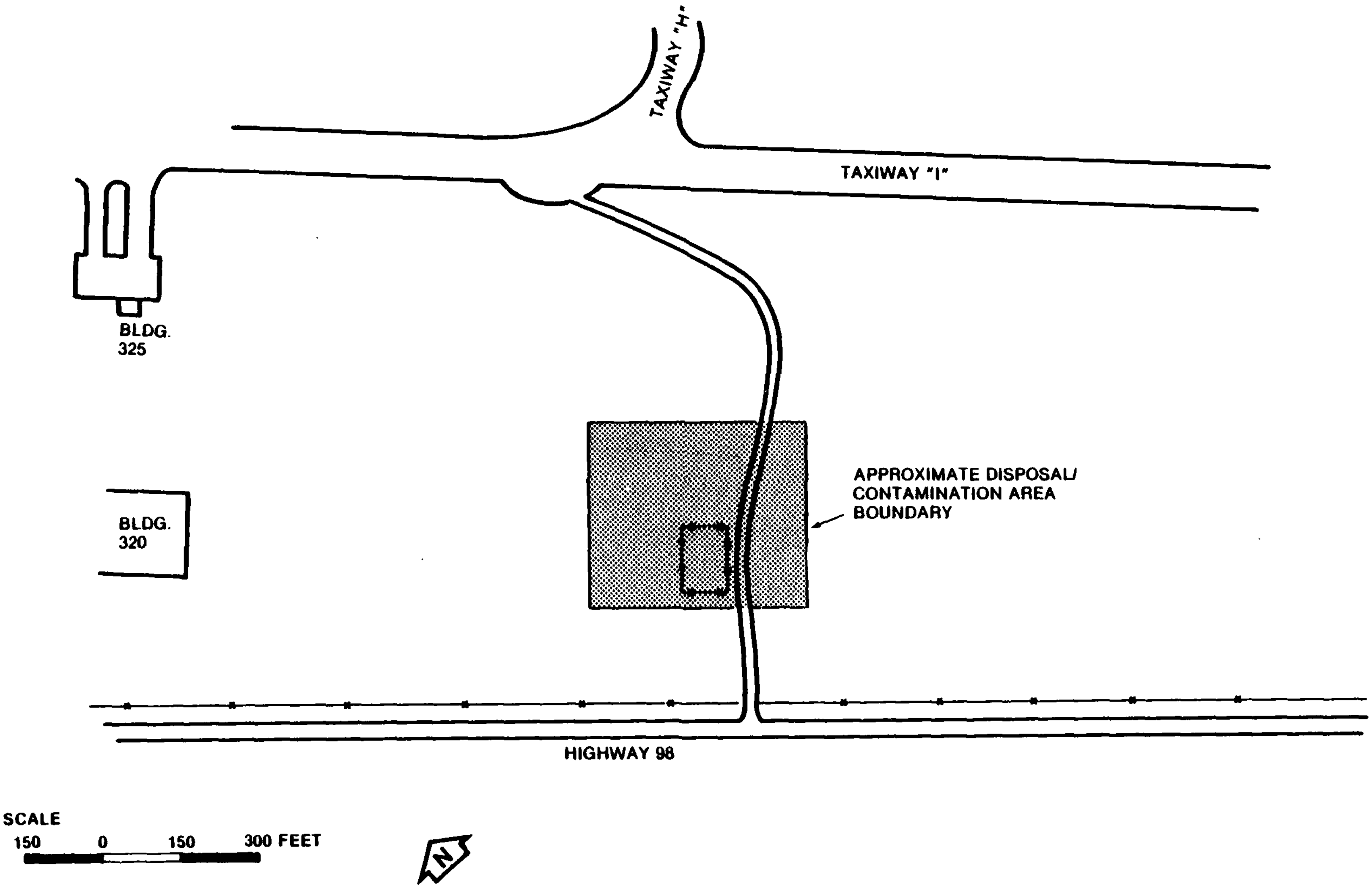

SOURCE: ESE, 1988.

Figure 1.5-5
SITE MAP FOR ZONE 6 — HIGHWAY 98 FIRE TRAINING AREA

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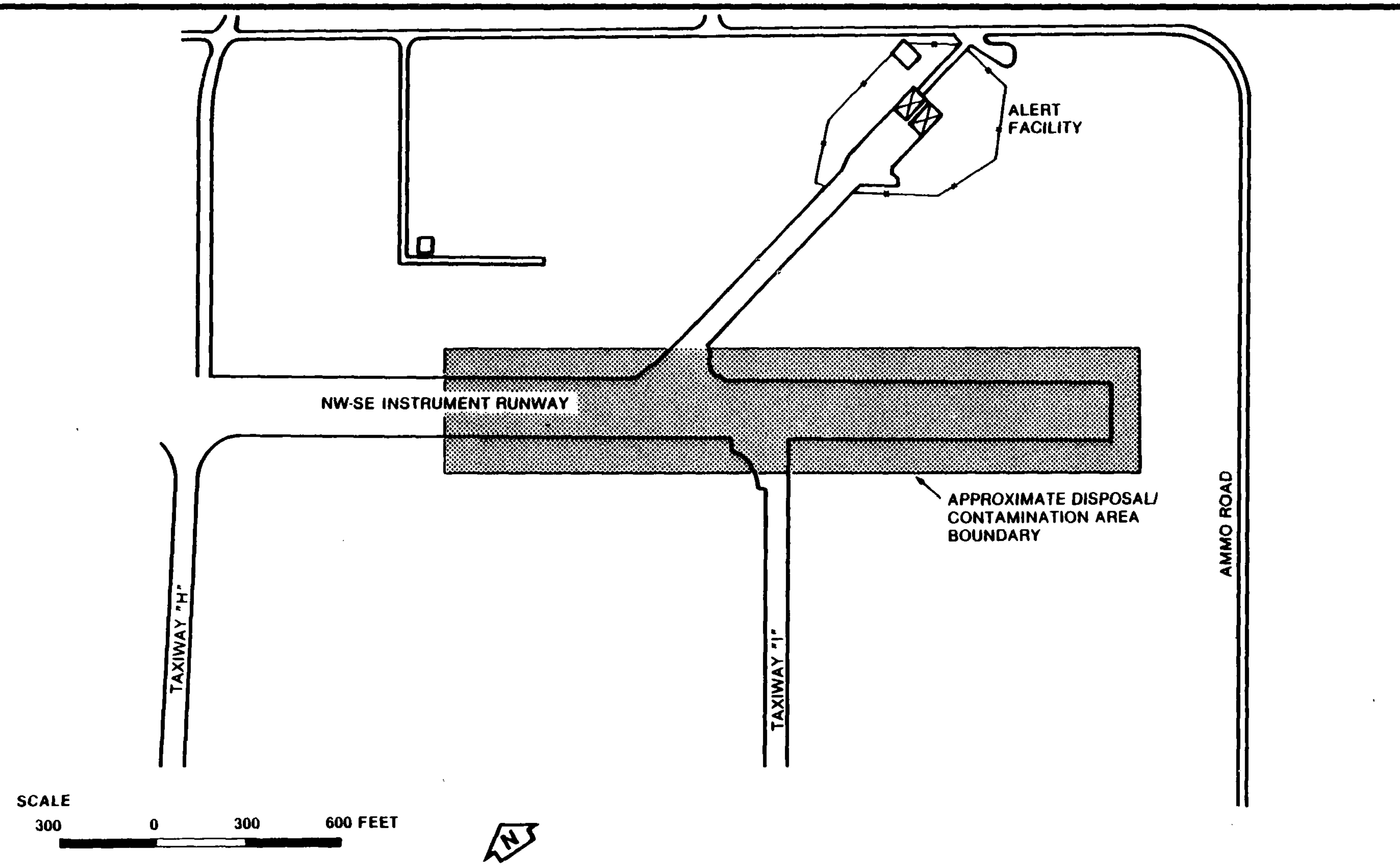
onto an old aircraft or simulated aircraft located in a bermed area and then set the aircraft on fire. Most of the POL waste was consumed in the fire; however, some minor percolation into the ground water may have taken place. It was reported by one interviewee that POL waste was sometimes taken to fire-training areas by flightline personnel and dumped into the bermed training area instead of the POL waste storage tank. Additional quantities of POL waste may have entered the ground water by this unauthorized practice, although total quantities are believed to be small. Prior to 1971, a protein foam was used to put out the fires. Since then, fire-fighting agents known as aqueous film-forming foams (AFFFs) have been used. AFFFs are noncorrosive and consist of fluorocarbon surfactants with petroleum-base foam stabilizers. Unknown quantities of AFFFs may have percolated into the ground during fire-fighting exercises.

Analytical results from the Phase II, Stage 1 study for this site indicate a wide range of contaminants in the surficial aquifer including lead, organics, and phenolics.

1.5.5 ZONE 7--SOUTHEAST RUNWAY EXTENSION BURIAL SITE

Zone 7, referred to as the Southeast Runway Extension Burial Site, was reported by one of the interviewees to have been used intermittently from 1945 to 1965 for disposal of used containers, drums, old batteries, and old parts (see Fig. 1.5-6). No information was found to indicate the quantity of material disposed in this area or if the drums and containers were empty. Apparently, the material was placed in narrow, excavated trenches. Some of this material was encountered in borings made for construction of the southeast runway extension. Information on past industrial operations indicates that the industrial shops, which generate the majority of hazardous wastes such as chlorinated solvents, were not in operation during this time.



SOURCE: ESE, 1988.

Figure 1.5-6
SITE MAP FOR ZONE 7 — SOUTHEAST RUNWAY EXTENSION LANDFILL

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Analytical results from the Phase II, Stage 1 survey indicate various organics are present at this zone; however, this requires confirmation. Analytical results for DOC and total phenolics were also positive at this zone.

1.5.6 ZONE 8--"6000" AREA LANDFILL

Zone 8, referred to as the "6000" Area Landfill, is located south of the pavements and grounds area of the base (Fig. 1.5-7). During the Phase I records search, several interviewees indicated that old parts, batteries, and empty containers were dumped intermittently in this area from 1945 to 1965. Visual inspection of the site during the Phase I records search revealed a cleared area of approximately 3 acres covered with vegetation, indicative of former disturbed soil conditions which may have resulted from a landfill operation. Aerial photographs obtained from the Base Civil Engineering Squadron during the Phase II, Stage 2 field effort indicate the landfill operation may have been somewhat larger.

Although lead was not detected at Zone 8 during the Phase II, Stage 1 investigations, DOC and TOX were found at the zone.

1.5.7 ZONE 9--POL AREA B

Zone 9, referred to as POL Area B, is located in the flightline area of the base near the Area "500" tank farm (Fig. 1.5-8). This POL area is a relatively small storage area which may have small amounts of sludge buried onsite. Lead was not detected in monitoring wells during Phase II, Stage 1 investigations, although TOX and DOC indicators suggest possible organic contamination.

1.5.8 ZONE 10--"SHELL BANK" FIRE TRAINING AREA

Zone 10, referred to as the "Shell Bank" Fire Training Area, was the original fire-training area and is located northwest of the main instrument runway near Shoal Point Bayou (Fig. 1.5-9). This site was used from 1943 to 1952, and again from 1968 to 1980.

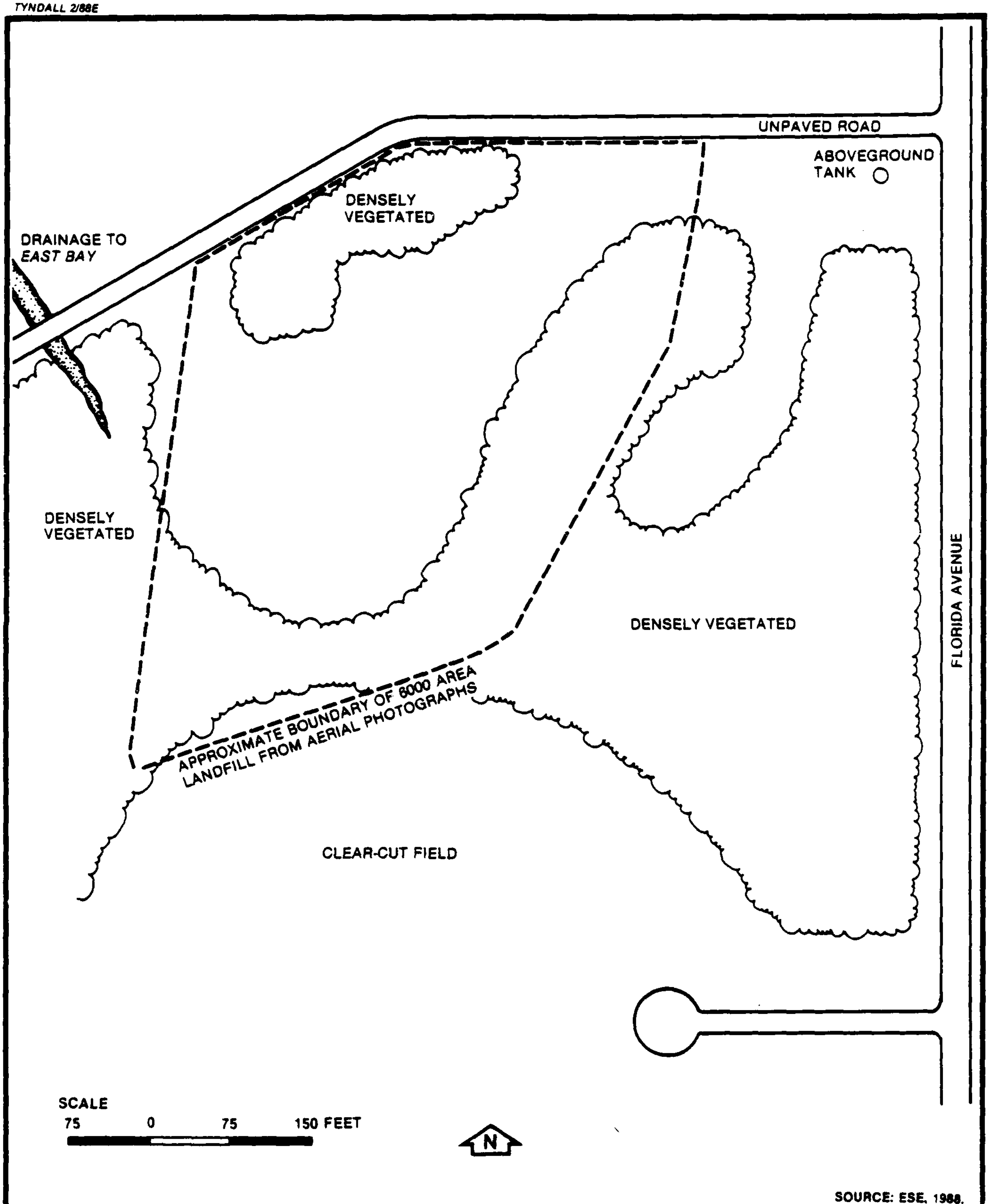

Figure 1.5-7
SITE MAP FOR ZONE 8 — "6000" AREA LANDFILL

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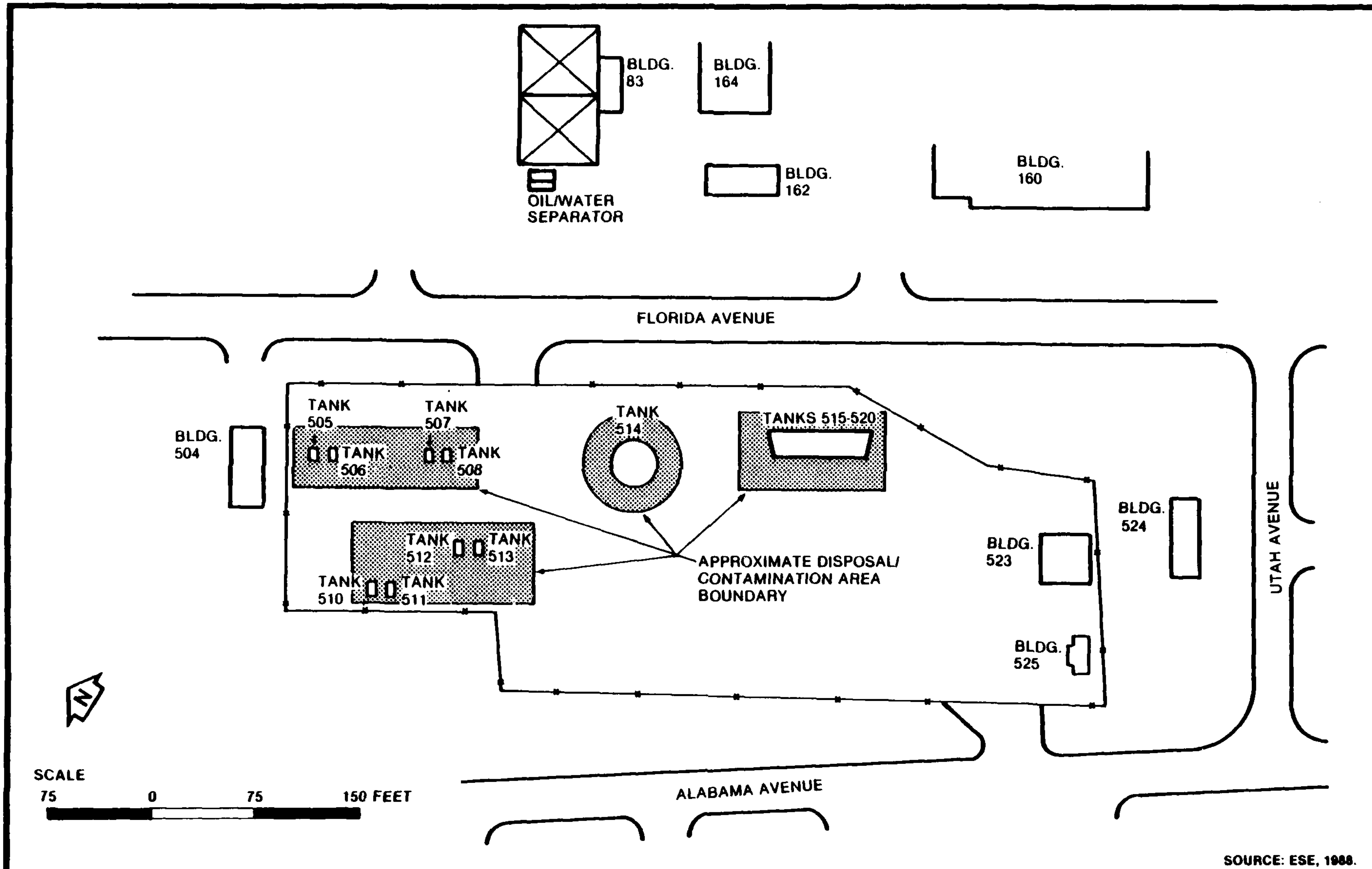

Figure 1.5-8
SITE MAP FOR ZONE 9 — POL AREA B

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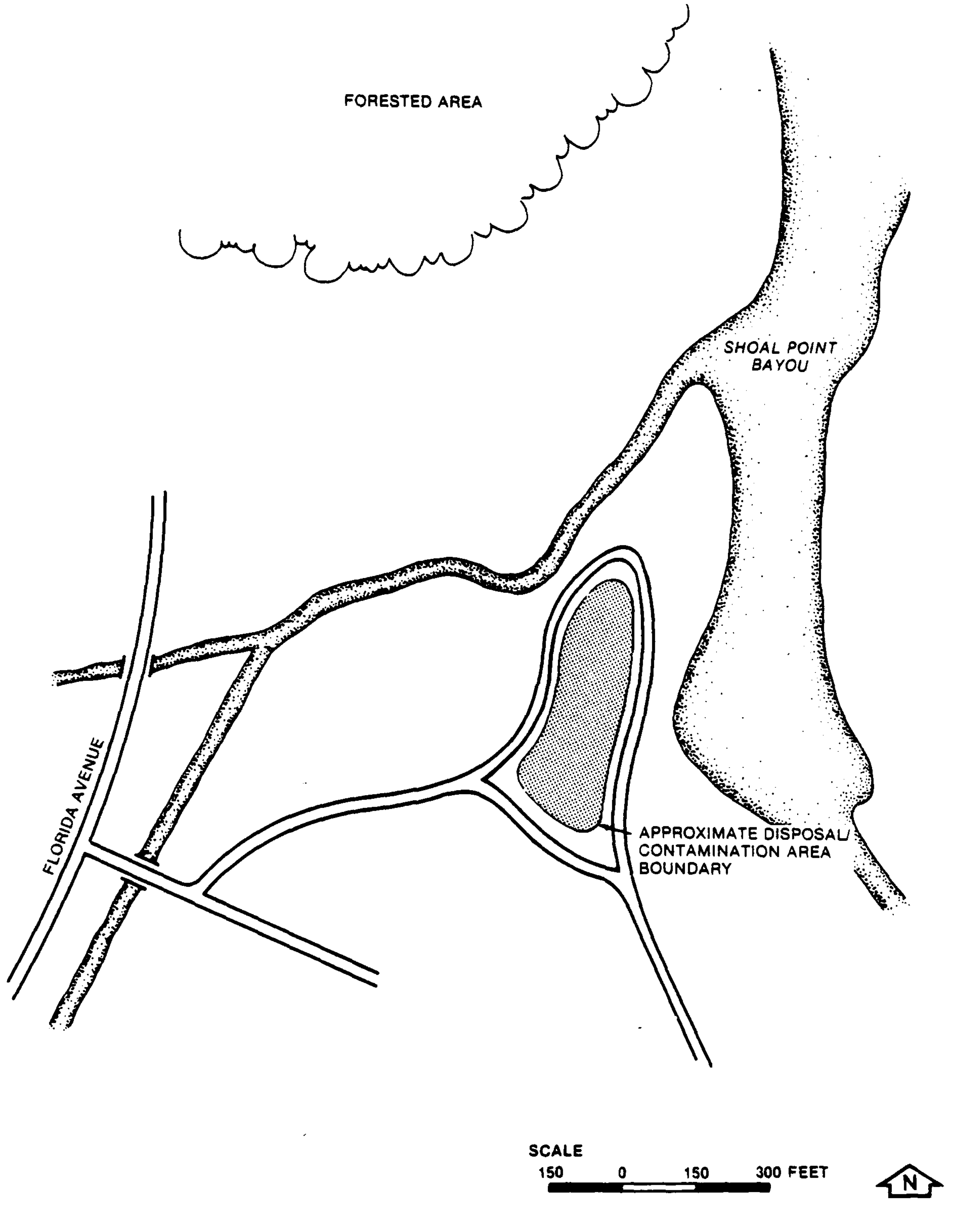

SOURCE: ESE, 1988.

Figure 1.5-9 **SITE MAP FOR ZONE 10—** **"SHELL BANK" FIRE TRAINING AREA**	**INSTALLATION** **RESTORATION PROGRAM** **Tyndall Air Force Base**

Zone 10 was a main repository for POL waste from industrial operations at Tyndall AFB in the past. POL waste was transported to this area and deposited in two 20,000-gal storage tanks. The POL waste was then sold to contractors or used in fire-training exercises. The two 20,000-gal storage tanks were located at Zone 10 in 1968 and subsequently removed in 1980. Standard procedure for the fire-training exercises was to pour POL waste onto an old aircraft or simulated aircraft located in a bermed area and then set the aircraft on fire. Most of the POL waste was consumed in the fire; however, some minor percolation into the ground water may have taken place. It was reported by one interviewee that POL waste was sometimes taken to fire-training areas by flightline personnel and dumped into the bermed training area instead of the POL waste storage tank. Additional quantities of POL waste may have entered the ground water by this unauthorized practice, although total quantities are believed to be small.

Results of the Phase II, Stage 1 investigations showed TOX, DOC, and total phenols to be present at the zone.

1.5.9 ZONE 11--ACTIVE FIRE TRAINING AREA

This previously uninvestigated site has been in use since 1981 as a fire-training area (see Fig. 1.5-10). Structures at the site include a fuel storage tank, a concrete-lined training pit where fires are set and extinguished, and an oil/water separator that discharges wastewater to Little Cedar Bayou, which drains surface runoff away from the adjacent air field. This fire training facility was active during the October 1986 field investigation. Current fire training exercises use only pure JP-4, and no waste fuel is burned.

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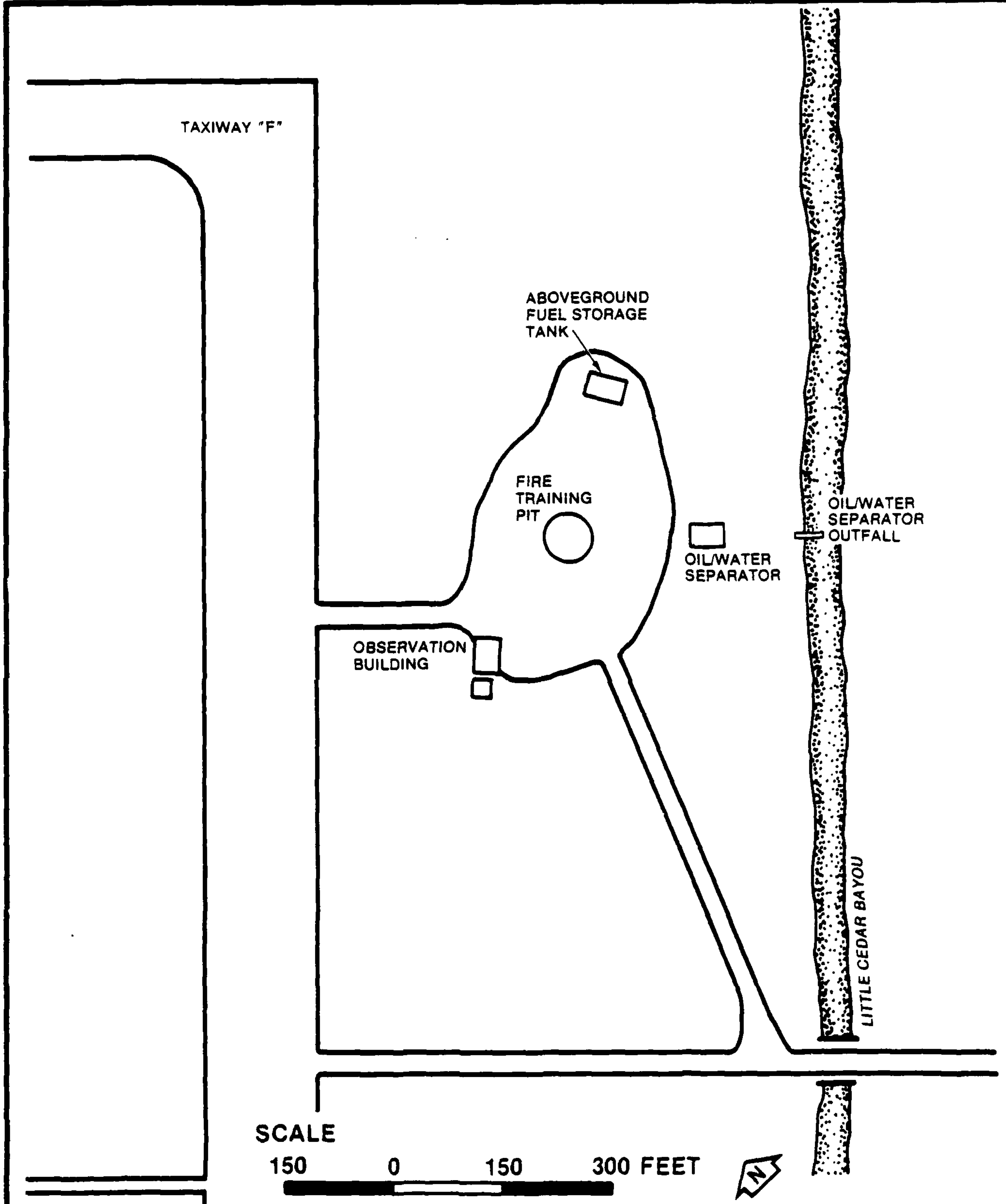

SOURCE: ESE, 1988.

Figure 1.5-10 **SITE MAP FOR ZONE 11 — ACTIVE FIRE TRAINING AREA**	**INSTALLATION RESTORATION PROGRAM** **Tyndall Air Force Base**

2.0 ENVIRONMENTAL SETTING

Tyndall AFB is located on the Gulf of Mexico coastline in the central part of the Florida Panhandle. This area is part of the lower Gulf Coastal Plain regional physiographic province, which extends from western Florida to southern Texas.

Tyndall AFB lies entirely inside Bay County, Florida, and is underlain by extensive deposits of sediments and sedimentary rocks which serve as both water-bearing and confining rock units. The lower coastal plain has been extensively modified by marine erosion and deposition associated with sea-level fluctuations that occurred during the Pleistocene. The Pleistocene is a stage of geologic time, ranging from 1.6 million to 100,000 years before the present, which was characterized by several periods of glacial advance and retreat. During glacial advances, fresh water was tied up in glacial ice sheets, which resulted in the lowering of sea level. Erosional features, such as incised drainage valleys, were developed during these low stands of sea level. As the glacial ice sheets retreated, sea level rose and much of the modern-day coastal plain was inundated by marine waters. Depositional features such as barrier islands, marshes, and tidal flats developed. At least four distinct glacial and interglacial cycles can be detected in the geologic record, with each modifying the geomorphological features of the Florida Gulf Coast. These geomorphic modifications control surface drainage patterns, water-table gradients, ground water movement, and depths to significant aquifers in the vicinity of Tyndall AFB.

2.1 TOPOGRAPHY

The topography of the region is characterized by geomorphic remnants of the Pleistocene glacial-eustatic sea-level fluctuations, which developed primary and secondary erosional and depositional landforms. The portions of the Gulf Coastal Plain inundated by the Gulf of Mexico during periods of elevated sea level have been referred to as the Coastal Lowlands by

Puri and Vernon (1964). The Coastal Lowlands display distinctive scarps and terraces, which roughly parallel the coastline. The Coastal Lowland complex can be subdivided into eight distinct terraces in the Bay County area based on elevation above sea level (Healy, 1975). Primary geomorphological features detectable on these terraces include relict barrier islands, lagoons, estuaries, beach ridges, and offshore bars whereas secondary features are generally erosional modifications of the primary landforms caused by surface drainage forces.

The eight distinct terraces of the Coastal Lowlands have been named and mapped based on the elevation of their occurrence. Tyndall AFB and Lynn Haven DFSP are underlain by the Silver Bluff Terrace, which ranges from 0 to 10 feet (ft) above sea level and the Pamlico Terrace, ranging from 10 to 25 ft above sea level. Tyndall AFB is located on a peninsula that extends along the shoreline of the Gulf of Mexico. The highest ground on the peninsula is 25 to 30 ft above mean sea level (msl) and occurs along a ridge which is part of the Pamlico Terrace. Lower lying areas fringing this ridge to the southwest and northeast are remnants of the Silver Bluff Terrace, which extends from 10 ft elevation down to msl.

Terraces play an important role in the hydrologic regimes of the Tyndall AFB area. The elevation of the terraces relative to adjacent land areas and bodies of water and the size or grading of sediments underlying the terraces are factors that affect the occurrence and movement of ground water. The water-table elevation and gradient generally reflect contours of the land surface. Therefore, terraces play a significant role in determining the configuration of the potentiometric surface. This was generally the case at all sites investigated on both Tyndall AFB and Lynn Haven DFSP. In addition, the fine-grained, permeable sands encountered at these sites allow rapid recharge from rainfall to occur by infiltration into the shallow sand aquifer.

A second classification scheme for physiographic features of the area was devised by Musgrove et al. (1965) and modified by Schmidt and Clark (1980). This classification scheme was based primarily on the land area's surface drainage and water storage characteristics. Four distinct divisions were provided for Bay County, with Tyndall AFB and Lynn Haven DFSP occurring in the "Flat-woods Forest" and the "Beach dunes and wave-cut bluffs" provinces. The "Flat-woods Forest" is slightly rolling to flat land lying on the terraces below an elevation of 70 ft. Most of this division is covered with pines, except for the areas cleared for agriculture. The "Flat-woods Forest" is moderately to well drained, with the exception of low areas around the bays of the Silver Bluff and Pamlico Terraces. During rainy weather these low areas of the flat woods become inundated. A few small perennial swamps occur at various locations throughout the "Flat-woods Forest." The "Beach dunes and wave-cut bluffs" province occurs adjacent to the Gulf Coast and is the youngest of the four physiographic divisions of this classification scheme. This province is characterized by dunes and beach ridges, estuaries, lagoons, and wave-cut scarps.

2.2 METEOROLOGY

The geographical position of Bay county, located near 30° north latitude, is reflected in the humid, sub-tropical climate of the area. The county has an annual average temperature of 68 degrees Fahrenheit (°F), varying from an average of 53°F in January to an average of 82°F in July (Schmidt and Clark, 1980). The annual average temperature at Tyndall AFB is 69°F, with an average daily maximum and minimum of 77°F and 61°F, respectively (see Table 2.2-1). The Gulf of Mexico, with an average annual water temperature of 73°F, has a stabilizing effect on the climate of the base. Warm, humid subtropical conditions are prevalent for much of the year, with convective storms and hurricanes playing a dominant role in summer and fall weather patterns. Summer temperatures are moderated by the Gulf breeze and by cumulus clouds, which frequently shade the land without completely obscuring the sun. Temperatures of 90°F or higher have

Table 2.2-1. Meteorological Data Summary For Tyndall AFB

Parameter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature (°F)													
Average Maximum	63	65	69	76	83	87	89	89	87	80	71	64	77
Average Minimum	46	49	54	61	68	74	76	75	72	63	53	47	61
Mean	55	57	62	69	76	81	83	82	79	71	62	56	69
Sea Temperature (°F)													
Mean	62	62	64	70	76	80	82	84	82	76	72	66	73
Precipitation (inches)													
Mean	3.56	3.47	5.26	4.34	2.43	4.94	8.14	7.07	6.13	3.05	3.16	3.64	55.19
Relative Humidity (%)													
Mean	76	75	74	74	75	76	77	77	76	71	72	74	75
Surface Winds (kn)													
Prevailing	8	11	12	10	8	7	8	7	7	8	8	8	-
Peak	47	52	46	55	42	60	56	68	69	40	43	42	-

Note: kn = knots.

Sources: Tyndall AFB Weather Office, 1948-1980.
ESE, 1988.

occurred in June, July, August, and September; however, 100°F is reached only rarely. In July and August, the warmest months, the average maximum temperature is 89°F. Temperatures of about 95°F occur on fewer than 6 days [U.S. Soil Conservation Service (USSCS), 1984]. During the winter season, occasional cold fronts move south from temperate latitudes, bringing winter rains and occasional freezing temperatures. The coldest weather generally occurs on the second night after the arrival of a cold front, after heat is lost through radiation. The average date of the first killing frost is about November 29. The average date of the last killing frost is about March 3. Frost has occurred, however, as early as November 5 and as late as April 10 (USSCS, 1984).

Tyndall AFB has an average rainfall of 55.2 inches (see Table 2.2-1), with approximately 125 days of recordable precipitation during the year. Greatest rainfall occurs between June and September with other, smaller peaks in December and March. Most thunderstorm activity occurs during the months of June, July, and August. Because the air is moist and unstable, showers are frequent and generally of short duration. During summer months, thunderstorms occur an average of 1 to 3 days each week. Sometimes 2 to 3 inches of rain falls within a period of 1 to 2 hours. Rain lasting all day is rare in summer. Winter and spring rains generally are not so intense as the summer thundershowers. Occasionally, heavy rain and high winds accompany the passage of a tropical disturbance or hurricane. Hail falls occasionally during thunderstorms, but is generally small and seldom causes damage. Snow is extremely rare.

Fog occurs on an average of six mornings a month in winter and spring and almost never occurs in summer and fall. Prevailing winds are generally from the south or southwest. In November, December, and January, winds are from the northwest. The annual mean windspeed for Bay County is about 6.5 kn. The lowest monthly windspeed, 5.4 kn, occurs in August. The highest windspeed, 7.8 kn, occurs in March. Wind speeds are slightly

greater at Tyndall AFB than the remainder of Bay County due to the close proximity to the Gulf of Mexico. Peak winds as high as 69 kn have been recorded at the Tyndall AFB flightline.

2.3 REGIONAL GEOLOGY AND HYDROLOGY

2.3.1 REGIONAL GEOLOGIC SETTING

Bay County is located in the central part of the Florida Panhandle and is part of the eastern Gulf of Mexico sedimentary basin consisting of southern Alabama, southern Georgia, and western Florida (Schmidt and Clark, 1980). The Apalachicola Embayment, a sub-basin of the Gulf of Mexico sedimentary basin, is the main geologic structure influencing the sediments which are found in the subsurface throughout Bay County. Bay County is situated on the western flank of the Apalachicola Embayment, which is centered on the western Apalachicola River and extends offshore. Sediment accumulation in the embayment attains a thickness of nearly 15,000 ft and ranges in age from Triassic to Recent (Applegate et al., 1978). Underlying these sediments are Paleozoic metamorphic rocks and Precambrian igneous rocks, which constitute the basement of the basin.

2.3.2 STRATIGRAPHY

A generalized stratigraphic column for Bay County with lithologic descriptions of rock units and associated hydrologic units is provided in Fig. 2.3-1. Two shallow geologic cross sections in the vicinity of Tyndall AFB are illustrated in Fig. 2.3-2. The uppermost sediments are sands and gravels of Pleistocene to Holocene age. These sediments, approximately 100 ft thick underlying Tyndall AFB, were deposited on the marine terraces which developed during the extensive sea-level fluctuations discussed in Sec. 2.1. Boreholes drilled during the installation of shallow monitor wells (20-ft depth) for the field survey of this investigation dominantly encountered clean, fine-grained quartz sands and clayey sands. These sediments comprise the upper portion of the surficial aquifer in the vicinity of Tyndall AFB and Lynn Haven DFSP.

ERA	EPOCH	LITHOLOGIC ROCK UNITS	HYDROLOGIC UNITS	DEPTH BELOW GROUND SURFACE (FEET)
CENZOIC	RECENT	UNDIFFERENTIATED QUARTZ SANDS	SURFICIAL AQUIFER	
	PLEISTOCENE	UNDIFFERENTIATED CLAYEY SANDS AND GRAVELS		100
	PLIOCENE	JACKSON BLUFF FORMATION CLAYEY SAND AND SANDY CLAY	REGIONAL AQUITARD	250
	MIOCENE	NUMEROUS DISTINCT LIMESTONE AND DOLOMITE UNITS WITH SOME SANDS AND CLAYS TOWARD THE BASE OF THE SECTION	FLORIDAN AQUIFER	
	OLIGOCENE			
	EOCENE			800
	PALEOCENE		NOT UTILIZED AS A SOURCE OF GROUND WATER	3,000
MESOZOIC		EXTENSIVE DEPOSITS OF DOMINANTLY SANDSTONES AND SHALES WITH SOME CLAYS, LIMESTONES, AND CHALK		11,000
PALEOZOIC		METAMORPHIC ROCKS		13,000
PRECAMBRIAN		GRANITIC ROCKS		

NOT TO SCALE

SOURCE: ESE, 1988.

Figure 2.3-1
STRATIGRAPHIC COLUMN OF LITHOLOGIC AND HYDROLOGIC UNITS UNDERLYING TYNDALL AFB

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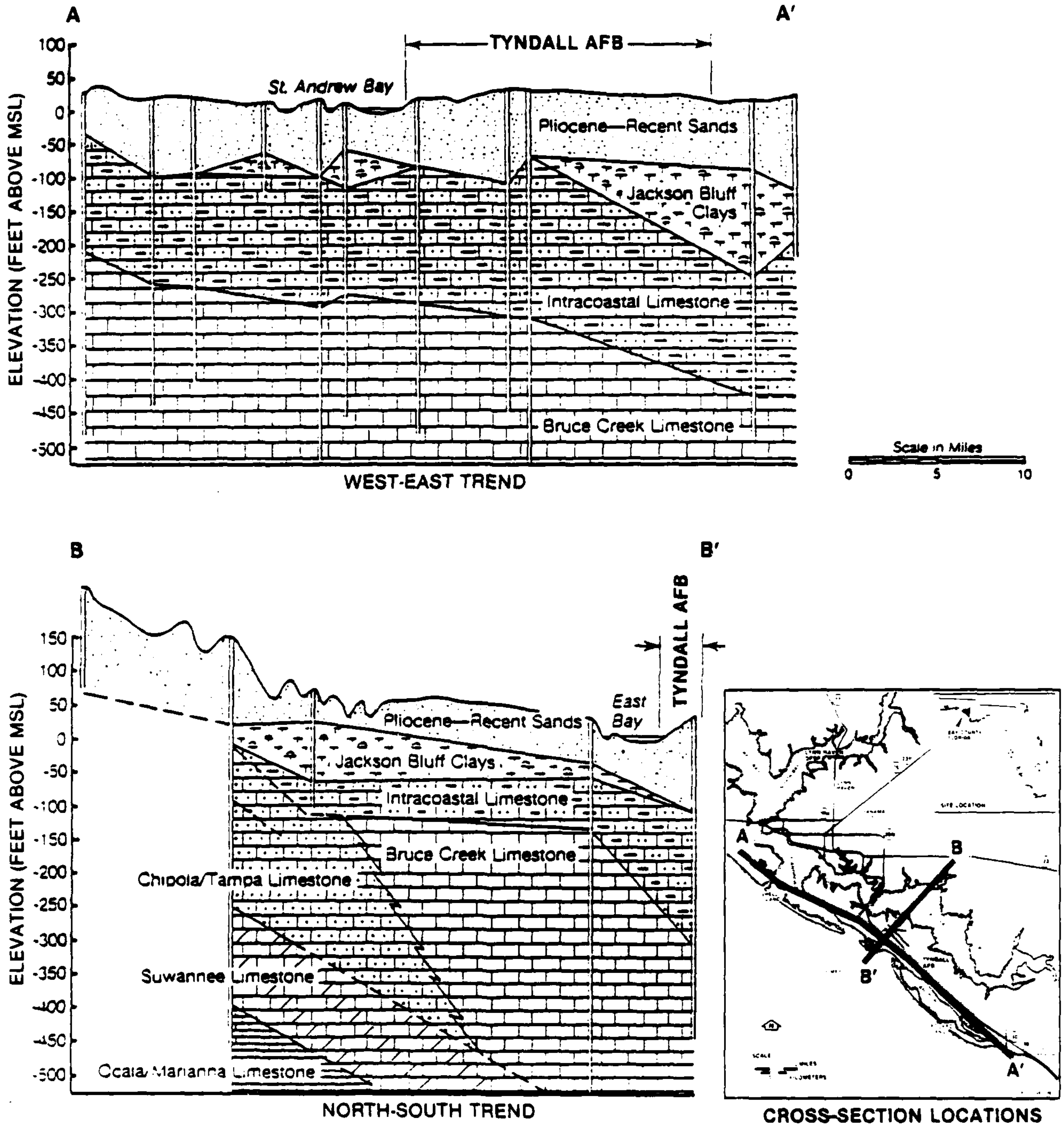

SOURCE: Florida Bureau of Geology, Bulletin 57.

Figure 2.3-2
TYPICAL GEOLOGIC CROSS SECTIONS, BAY COUNTY

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Underlying the surficial sands and gravels is the Pliocene-Age Jackson Bluff Formation, a calcareous, sandy clay to clayey sand (Schmidt and Clark, 1980). The Jackson Bluff Formation serves as a significant aquitard in portions of Bay County, but its effectiveness as such in the Tyndall AFB area is questionable. Lithologic logs from deep water supply wells located on Tyndall AFB show only relatively thin (<20 ft thick) clay layers, whereas other deep well logs on Tyndall AFB do not indicate the presence of any significant clay layers. Whereas the Jackson Bluff Formation provides an effective aquitard in northern Bay County, based on available data it cannot be assumed that a similar confining horizon exists between the surficial and Floridan Aquifers underlying Tyndall AFB.

The Jackson Bluff Formation is underlain by numerous distinct limestone and dolomite units that range in age from Paleocene to Early Pliocene. These calcareous rocks are roughly 2,800 ft thick in the vicinity of Tyndall AFB. The uppermost 250 to 500 ft of these limestone units comprise the Floridan Aquifer, which is the major source of fresh ground water in the region. Below this depth the water tends to become saline, with the total thickness of the fresh water zone increasing in a landward direction away from the Gulf of Mexico. Therefore, saline waters would be encountered at a shallower depth at Tyndall AFB than at Lynn Haven DFSP.

The above-mentioned lithologic units comprise the Cenozoic age section, which is underlain by approximately 8,000 ft of Mesozoic rocks. These Mesozoic rocks are dominantly sandstones and shales with minor occurrences of limestone in the uppermost sequences. Due to the excessive depth of these rocks and the existence of abundant fresh water in the overlying rock units, these Mesozoic rocks are not utilized as sources of ground water in Bay County. Underlying the Mesozoic rocks are Paleozoic metamorphic rocks and Precambrian igneous rocks, which constitute the basement of the basin.

2.3.3 SOIL TYPES

The term "soil" generally refers to the uppermost cover of the ground surface extending downward to the lower limit of biochemical alteration of existing sediments. Biochemical alteration occurs from vegetative processes as well as leaching and physical weathering of these sediments. Soil types affect surface runoff, infiltration and percolation rates, and recharge and discharge of ground water. Tyndall AFB and Lynn Haven DFSP are underlain by soils of the Pottsburg-Leon-Rutledge association, which are common to the low flatwoods physiographic complex (USSCS, 1984). This soil association is characterized by nearly level, poorly to moderately drained sandy soils extending to a depth of 80 inches or more, often containing organic-stained layers. The landscape is generally level with scattered swamps, depressions, and poorly defined drainageways.

Areas of Tyndall AFB along East Bay are underlain by tidal marsh soils of the Bayvi-Dirego association (USSCS, 1984). These areas are characterized by nearly level, poorly drained soils; some are sandy to a depth of 80 inches or more, whereas others are organic to a depth of 14 to 50 inches and are sandy below. These soils are generally covered by salt-tolerant vegetation and subjected to periodic tidal flooding.

2.3.4 SURFACE WATER HYDROLOGY

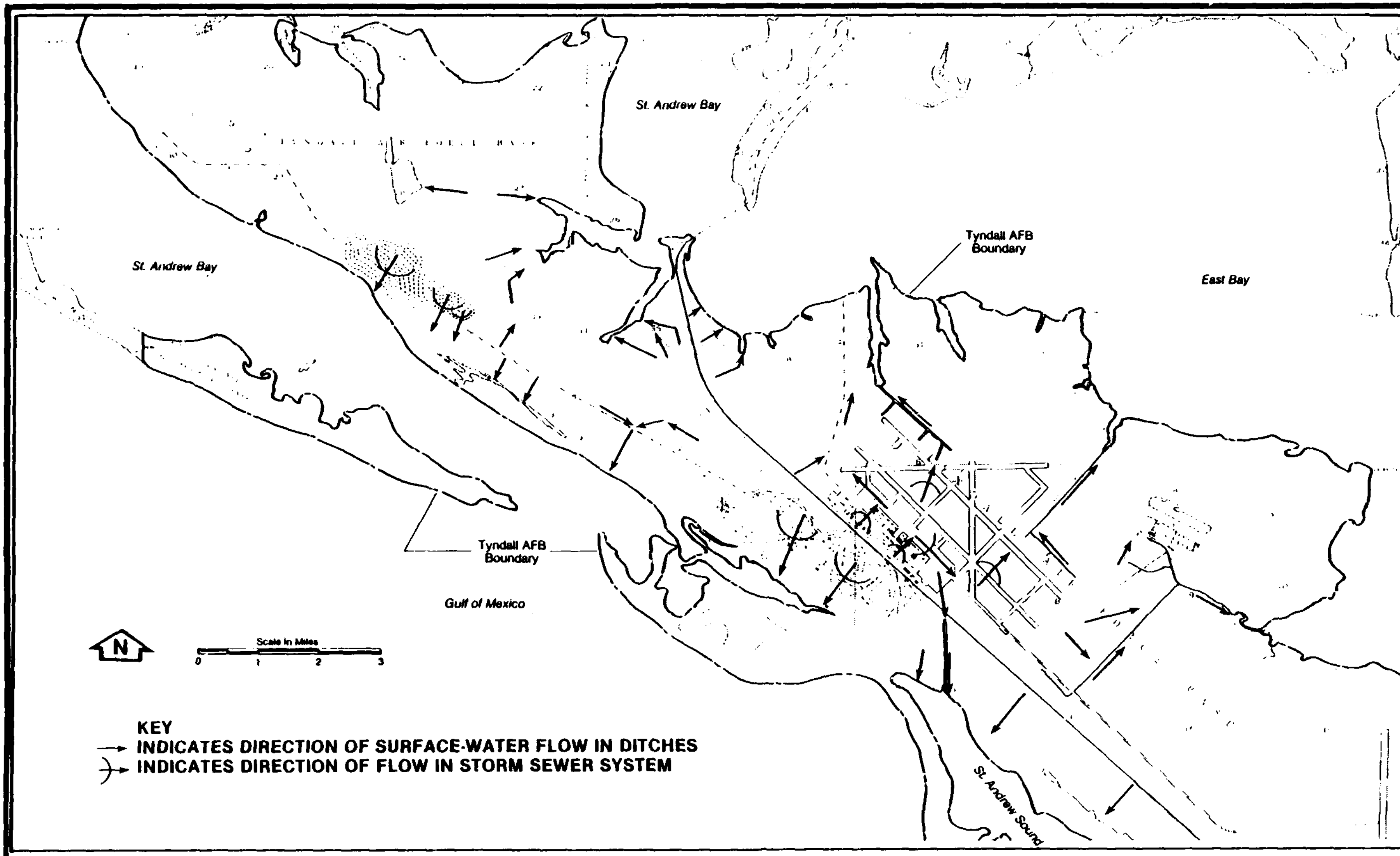
Much of Bay County is within the Econfina Creek watershed, which flows into an estuarine complex consisting of West Bay, North Bay, East Bay, and St. Andrew Bay. Precipitation falling at Tyndall AFB and surrounding areas percolates either into the ground directly or flows across the ground surface into adjacent water bodies. At Lynn Haven DFSP, surface water runoff flows into North Bay. On Tyndall AFB, runoff from areas on the north side of U.S. Highway 98 flows into man-made drainageways and natural creeks and bayous eventually emptying into East Bay, whereas areas on the south and west sides of U.S. Highway 98 drain into St. Andrew Sound, St. Andrew Bay, and the Gulf of Mexico.

In the vicinity of the flightline, the maintenance and administrative areas, and family housing areas, the predominant surface-water drainage features consist of storm sewers and ditches. Surface drainage features and directions of drainage runoff are shown in Fig. 2.3-3.

2.3.5 GROUND WATER HYDROLOGY

Ground water in Bay County exists under both unconfined (water-table aquifer) and confined (Floridan Aquifer) conditions. The water-table aquifer, also referred to as the surficial aquifer, ranges from 100 to 120 ft thick in the vicinity of Tyndall AFB and is approximately 50 ft thick underlying Lynn Haven DFSP. The surficial aquifer is separated from the deeper Floridan Aquifer by the Jackson Bluff Formation, a sandy clay unit which varies in thickness from approximately 0 to 150 ft across Bay County. The extent of this formation and its ability to serve as an effective aquitard in the Tyndall AFB area is questionable, as described in Sec. 2.3.3 of this report. The thickness of the Jackson Bluff Formation underlying Lynn Haven DFSP is unknown. The Floridan Aquifer is composed primarily of limestone, with potable water supplies obtainable from 250- to 500-ft depths in the vicinity of Tyndall AFB and somewhat deeper at Lynn Haven DFSP.

The surficial aquifer is composed primarily of quartz sand, with clayey sand and sandy clay lenses occurring sporadically (Schmidt and Clark, 1980). Permeability values for this aquifer provided by Hatch et al. (1981) were on the order of 0.01 centimeters per second (cm/sec). The water table generally follows the land surface configuration as a subdued expression of the surface topography, with flow moving downgradient from the elevated coastal ridge along U.S. Highway 98. This regional pattern of ground water movement is affected locally by bayous, streams, and ditches, where the ground water flows directly to these surface waters. The water-table elevation rises during periods of heavy rainfall and declines during periods of low rainfall; yearly fluctuations



SOURCES; Hatch *et al.*, 1981.
ESE, 1988.

Figure 2.3-3
SURFACE DRAINAGE AT TYNDALL AFB

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of approximately 5 ft are typical. The average depth to ground water varies from about 1 to 10 ft over most of Tyndall AFB, but may be as deep as 15 ft near the coastal ridge along U.S. Highway 98.

Due to the chemical characteristics of the quartz sands of the surficial aquifer, the mineral content of the water is relatively low. Wells tapping this aquifer, however, do show elevated concentrations of iron and occasionally yield slightly acidic water (Schmidt and Clark, 1980).

Leachate from any landfill or disposal area on Tyndall AFB would probably travel downward to the water-table aquifer, then follow the local pattern of ground water movement, ultimately discharging into streams, bayous or ditches, or directly to the bays surrounding the peninsula. Even though the soils in the Tyndall AFB area are moderately permeable, the rate of migration of any contaminant plume would be relatively slow due to the gradual slope of the water table.

The second aquifer system at Tyndall AFB, the Floridan Aquifer, consists of limestones and dolomites. The top of the Floridan Aquifer underlying Tyndall AFB is approximately 250 ft below sea level. The aquifer is roughly 1,100 ft thick, but potable water is derived only from the upper 250 to 500 ft of the aquifer. Hatch et al. (1981) reported that the average transmissivity of the Floridan Aquifer is estimated to be about 100,000 gallons per day (gpd) per foot.

The Floridan Aquifer is under artesian conditions; therefore, water levels in wells completed in this formation rise above the top of the aquifer. Water levels in 1985 in Bay County are indicated on the potentiometric surface contour map in Fig. 2.3-4. Pumping from emergency supply wells on the base can cause localized depressions in the potentiometric surface, including lowering of the surface below msl, depending on the rate of pumping. The main water supply for Tyndall AFB,

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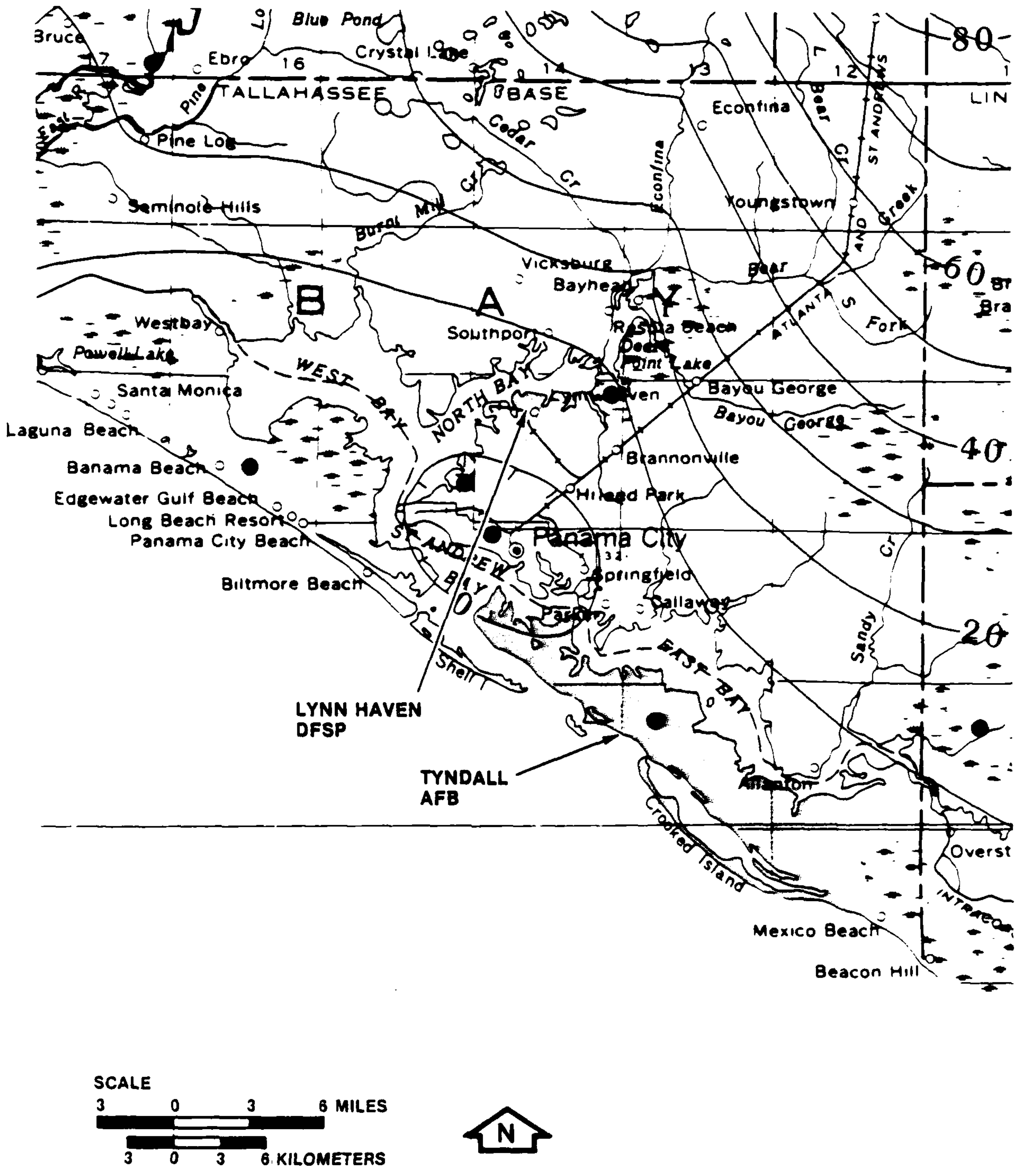


SOURCE: Rosenau and Meadows, 1986.

Figure 2.3-4 POTENTIOMETRIC SURFACE OF THE FLORIDAN AQUIFER SYSTEM IN BAY COUNTY, MAY 1985	INSTALLATION RESTORATION PROGRAM Tyndall Air Force Base

however, is obtained from Bay County. Schmidt and Clark (1980) report that Panama City changed to a surface water supply in 1967 because of concerns about continually declining water levels in wells and the increased potential for saltwater intrusion.

Most of the water in the Floridan Aquifer in south Bay County originates in Washington, Holmes, and Jackson Counties in Florida and in southern Alabama. Local recharge is effectively prevented in much of Bay County by the Jackson Bluff Formation. Water within the Floridan Aquifer flows in a southwesterly direction beneath the Tyndall AFB peninsula and eventually discharges into the Gulf of Mexico.

The presence of large saltwater estuaries in the vicinity of both Tyndall AFB and Lynn Haven DFSP provides an access for salt water to inland areas. The potential for saltwater intrusion into ground water exists from these estuaries and the associated tributaries. This salt water is in contact with sands of the surficial aquifer, where localized elevated chloride concentrations have been documented in this aquifer by Musgrove et al. (1965). Salt water from the estuaries and/or tributaries may be responsible for the existence of elevated inorganic or organic constitutents detected in the facility monitor wells. Chloride also has been reported at elevated levels in portions of the uppermost Floridan Aquifer.

2.4 LOCATION OF OFFSITE AND ONSITE WELLS

2.4.1 LOCATION OF OFFSITE WELLS

The majority of Bay County is served by the Bay County Water Supply System, which obtains its water supply from Deer Point Lake. This surface water reservoir is the exclusive source of water for the municipalities of Panama City, Springfield, Parker, Callaway, Cedar Grove, and Hiland Park. None of these areas operates wells that are tapping ground water for the purpose of public water supplies. Major industries, however, do utilize wells to provide water for industrial processes in some of these areas.

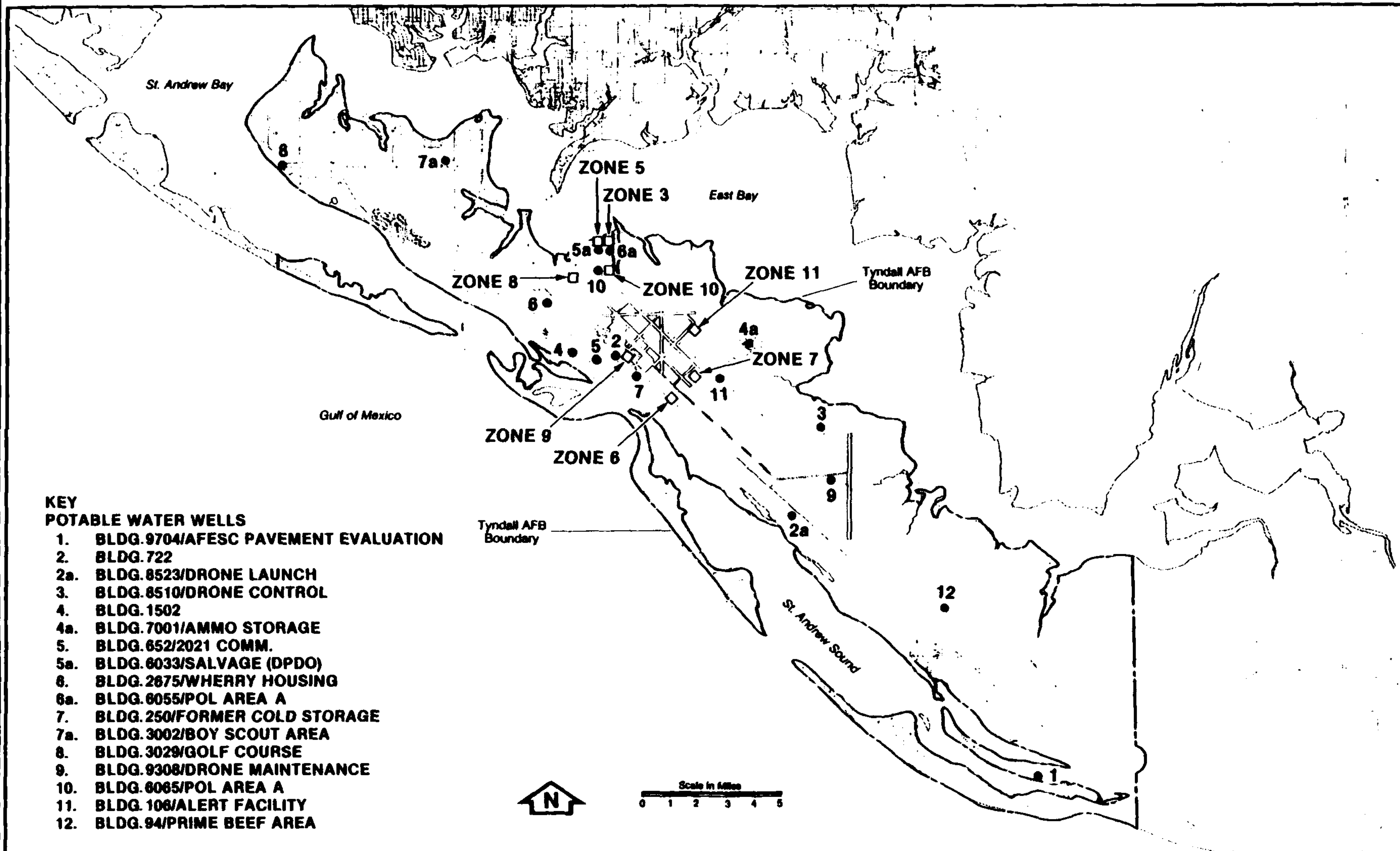
The closest public water supply wells are located approximately 12 miles northwest of Tyndall AFB. These wells are not downgradient from the Tyndall AFB and could not be impacted by migration of contaminants from contaminated sites onbase. However, contamination which leaked vertically into the Floridan Aquifer from the Lynn Haven DFSP would also travel southwest in the direction of the regional flow, and could potentially impact downgradient wells in Panama City Beach or unincorporated areas of Bay County.

Panama City Beach mixes surface water obtained from the county water supply system with ground water derived from deep wells within Panama City Beach. These wells are not downgradient from Tyndall AFB and are more than 8 miles from the Lynn Haven DFSP. The municipality of Lynn Haven uses ground water exclusively as its source of public water supplies, with water obtained from the Floridan Aquifer at depths of 400 to 800 ft. The closest municipal well to Lynn Haven DFSP is approximately 1 mile away. All wells serving the municipality of Lynn Haven are crossgradient or upgradient from the fuel storage facility, and routine monthly analyses have never detected any contamination of the water supply.

All unincorporated areas of Bay County are served by private wells, including the neighborhoods of Northshore, Baywood Shore Estates, and Venetian Villa, which are 0.5 to 2.0 miles downgradient from the Lynn Haven DFSP. Wells in these areas are generally screened in the upper portion of the Floridan Aquifer at depths of 200 to 400 ft.

2.4.2 LOCATION OF ONSITE WELLS

Seventeen potable water wells exist on Tyndall AFB; their locations are indicated in Fig. 2.4-1. These wells are distributed across the entire base, ranging from the southeast corner of the base near Mexico Beach to the golf course at the extreme northwest portion of Tyndall AFB. The proximities of these wells to the eight zones on Tyndall AFB investigated



SOURCES: Hatch *et al.*, 1981.
ESE, 1988.

Figure 2.4-1
LOCATION OF SUPPLY WATER WELLS ON TYNDALL AFB

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by this report are provided in Table 2.4-1. Information provided by Tyndall AFB Bioenvironmental Services (BES), including building numbers where the wells are located, well usage, well depth, and productive intervals, is presented in Table 2.4-2.

The 17 wells range in depth from 115 to 658 ft, with the majority greater than 400 ft deep deriving water from the Floridan Aquifer. They are usually cased from the ground surface down to a point near the upper limit of the Floridan Aquifer, with the lower extent of the well uncased and open to the aquifer. Average daily withdrawal capacities range from 400 to 80,000 gallons (gal) depending on the depth, well diameter, and pump capacities. Wells 2, 5, 6, and 7 are capable of yielding a maximum of 240,000 gpd each.

Some wells were constructed in the early 1940s when the base became operational. Ground water from these wells provided the entire water supply for the base until the late 1960s, when Tyndall AFB changed to the Bay County Water Supply System for its source of water. The old network connecting the base wells to the base water distribution system is still intact.

The golf course clubhouse is the only base facility drawing water exclusively from a well. The water is softened and chlorinated. Bottled drinking water is used at all other remote facilities due to the poor quality (e.g., hardness) of the water. Six other wells are classified as "Potable Water for Remote Site," but are used to provide water only for toilet flushing purposes. Personnel in these areas use bottled water for drinking purposes.

Six other wells are currently classified as "inactive" and are not currently used as a source of water for any purpose. However, these wells have never been abandoned and could be reactivated in the event of an emergency or to meet future demands.

Table 2.4-1. Distance from On-base Supply Wells to Zones of Investigation† at Tyndall AFB

	Well No.																
Zone #	1	2	2A	3	4	4A	5	5A	6	6A	7	7A	8	9	10	11	12
3	*	*	*	*	*	*	*	900	*	0	*	*	*	*	200	*	*
5	*	*	*	*	*	*	*	500	*	1,200	*	*	*	*	1,000	*	*
6	*	*	*	*	*	*	*	*	*	*	2,800	*	*	*	*	4,200	*
7	*	*	*	*	*	3,600	*	*	*	*	*	*	*	*	*	0	*
8	*	*	*	*	*	*	*	250	5,000	1,300	*	*	*	*	750	*	*
9	*	850	*	*	3,400	*	2,400	*	*	*	3,200	*	*	*	*	*	*
10	*	*	*	*	*	*	*	1,800	*	1,300	*	*	*	*	1,200	*	*
11	*	*	*	*	*	4,000	*	*	*	*	*	*	*	*	*	5,000	*

*Distance is greater than 1 mile (5,280 ft).
†All distances in feet.

Source: ESE, 1983.

Table 2.4-2. Summary of Supply Wells on Tyndall AFB

WELL	LOCATION*	USE	DEPTH (ft)	PRODUCTION INTERVAL	DISTANCE FROM NEAREST ZONE INVESTIGATED BY THIS REPORT (ft)
1	Bldg. 9704	Potable water for remote site	570	NA	>5,280
2	Bldg. 722	Emergency backup for base distribution†	653	360 to 653	850
2A	Bldg. 8523	Potable water for remote site**	130	NA	>5,280
3	Bldg. 8510	Inactive	658	NA	>5,280
4	Bldg. 1502	Inactive	435	NA	3,400
4A	Bldg. 7001	Potable water for remote site**	435	280 to 435	3,600
5	Bldg. 652	Emergency backup for base distribution†	487	NA	2,400
5A	Bldg. 6033	Inactive	463	435 to 463	250
6	Bldg. 2675	Emergency backup for base distribution†	644	351 to 644	5,000
6A	Bldg. 6055	Inactive	580	NA	0
7	Bldg. 250	Emergency backup for base distribution†	645	345 to 645	2,800
7A	Bldg. 3002	Inactive	NA	NA	>5,280
8	Bldg. 3029	Potable water for remote site**	490	NA	>5,280
9	Bldg. 9308	Potable water for remote site**	430	NA	>5,280

Table 2.4-2. Summary of Supply Wells on Tyndall AFB (Continued, Page 2 of 2)

WELL	LOCATION*	USE	DEPTH (ft)	PRODUCTION INTERVAL	DISTANCE FROM NEAREST ZONE INVESTIGATED BY THIS REPORT (ft)
10	Bldg. 6065	Potable water for remote site**	600	316 to 600	200
11	Bldg. 106	Potable water for remote site	115	100 to 115	0
12	Bldg. 94	Inactive	521	500 to 521	>5,280

Note: NA = Not available.
*Well locations are shown in Fig. 2.4-1.
†Currently not permitted for use as supplemental source to county system except in the case of a National Defense Emergency.
**Potable water used for flushing toilets. Personnel use bottled water for drinking purposes.

Sources: BES, 1987.
ESE, 1988.

Two onbase wells exist at the Lynn Haven DFSP; both are used exclusively for the purpose of filling a 750,000-gal fire-protection reservoir. The Lynn Haven facility receives its drinking water supply from the City of Lynn Haven.

2.5 HISTORIC GROUND WATER AND SURFACE WATER MONITORING

The Bioenvironmental Engineering staff at Tyndall AFB is responsible for taking periodic samples from selected stormwater drainage ditches and onbase wells.

Samples from stormwater drainage ditches are analyzed quarterly at Tyndall AFB. These samples are routinely monitored for oil and grease and periodically monitored for heavy metals. Recent sampling results do not indicate the presence of hazardous contaminants at these stormwater sampling points.

Onbase wells are analyzed periodically for State of Florida Primary and Secondary drinking water parameters. Recent test results indicate satisfactory water quality with no indication of hazardous contaminants. Water quality data for onbase wells are contained in Appendix B.

3.0 FIELD PROGRAM

3.1 OVERVIEW OF FIELD PROGRAM

The Tyndall AFB Phase II, Stage 2 field program was developed based on findings and recommendations of the Phase I records search (Hatch et al., 1981) and the Phase II, Stage 1 investigation (Thiess et al., 1984). Additional information was also obtained by subsequent site surveys and discussions with USAF Occupational and Environmental Health Laboratory (OEHL) personnel. A summary of the Phase II, Stage 2 Monitoring and Analysis Work Plan is provided in Table 3.1-1. The complete scope of work defined by OEHL appears in Appendix C. The QA and safety plans for the Phase II, Stage 2 study are found in Appendixes D and E, respectively.

Field activities for the Phase II, Stage 2 investigation included the following tasks: geophysical surveying, piezometer installation and monitoring, monitor well installation and ground water quality monitoring, surface water quality monitoring, as well as soil and sediment sampling. This section details the field investigation methodology and program implementation at each of the nine zones investigated.

Surface geophysical techniques, including electromagnetic conductivity and magnetometry surveys, were used to determine the site boundaries, locate landfilled wastes, and conduct a preliminary identification of a leachate plume at Zone 8 ("6000" Area Landfill).

Piezometers were installed at five zones where less than three functional monitor wells existed to serve as observation wells in which ground water levels in the unconfined aquifer could be measured. Water-level data were used to determine ground water gradients and identify ground water flow directions. This information was used in determining appropriate

Table 3.1-1. Tyndall AFB Phase II, Stage 2 Monitoring and Analysis

Site Description	Monitoring/Analysis Description	Rationale
Zone 2—Lynn Haven DFSP	Install two additional downgradient monitor wells.	Replace damaged wells for purpose of sampling shallow ground water under zone (supplement to existing monitor well network).
	Collect seven ground water, one surface water, and one sediment sample and analyze all samples for:	
	Purgeable organics	Determine specific purgeable organics present at the site as a result of past fuel and waste disposal practices.
	Petroleum hydrocarbons	Oils and greases have been reportedly spilled or buried at this zone.
	Lead	Leaded fuel and AVGAS reportedly spilled or buried at this zone.
Zone 3—POL Area A	Install one upgradient and two downgradient monitor wells.	Supplement existing monitor well network for purpose of sampling shallow ground water.
	Collect seven ground water samples and analyze for:	
	Purgeable organics	Determine specific purgeable organics present at the zone as a result of past disposal of fuel sludges.
	Ethylene dibromide (EDB)	Determine presence of EDB, a component of AVGAS.
	Petroleum hydrocarbons	Fuel tank sludge was disposed in shallow trenches.
	Lead	Leaded fuel (AVGAS) sludge was disposed in shallow trenches.

Table 3.1-1. Tyndall AFB Phase II, Stage 2 Monitoring and Analysis (Continued, Page 2 of 5)

Site Description	Monitoring/Analysis Description	Rationale
Zone 8—"6000" Area Landfill	Install two piezometers.	Define the hydraulic gradient in the shallow aquifer.
	Conduct geophysical surveys (electromagnetic conductivity and magnetometry) across the site.	Determine site boundaries, locate landfilled wastes, and attempt preliminary identification of leachate plume extent.
	Install two downgradient monitor wells.	Supplement existing monitor well for purpose of sampling shallow ground water.
	Collect three ground water samples and analyze for:	
	Purgeable organics.	Identification of specific contaminants including solvents from the disposal of old parts and containers.
	Base/neutral and acid-extractable organics	Identification of pesticides, herbicides, phenolic compounds, and other contaminants, possibly dispersal.
	Priority pollutant metals	Old parts, batteries, and containers (some possibly containing paint) were disposed.
Zone 7—Southeast Runway Extension Burial Site	Collect four ground water samples (three monitor wells, one base well) and analyze for:	
	Purgeable organics.	Identify potential chlorinated solvent contamination due to disposal of containers and drums.
	Base/neutral and acid-extractable organics	Identification of potential pesticides, herbicides, polychlorinated biphenyls (PCBs), and phenolic compound contamination from disposal of used containers, drums, and old parts.
	Priority pollutant metals	Old parts, batteries, and drums were disposed at site in narrow excavated trenches.

Table 3.1-1. Tyndall AFB Phase II, Stage 2 Monitoring and Analysis (Continued, Page 3 of 5)

Site Description	Monitoring/Analysis Description	Rationale
Zone 5--Small Arms Repair Area	Collect three ground water samples and analyze for:	
	Purgeable organics	Solvents may have been disposed in open pit.
	Acid-extractable organics	Identification of waste paint and specific phenolic paint strippers disposed in open pit.
	Priority pollutant metals	Waste paints, potentially containing metals, were reportedly disposed of in open pit.
Zone 6--Highway 98 Fire Training Area	Install two piezometers.	Define the hydraulic gradient in the shallow aquifer.
	Install one upgradient and one downgradient monitor well.	Supplement existing monitor well network for purpose of sampling shallow ground water.
	Collect five ground water samples and analyze for:	
	Purgeable organics	Identify fuel and chlorinated solvent contamination associated with fire-training activities.
	Acid-extractable organics	Identification of phenolic paint strippers associated with disposal and fire-training activities.
	Petroleum hydrocarbons	Waste oil and grease may have been spilled during fire-training activities.
	Lead	Leaded fuel may have been spilled during fire-training activities.
Zone 9--POL Area B	Install one piezometer.	Augment existing water-level data to define the hydraulic gradient in the shallow aquifer.
	Install one upgradient and one downgradient monitor well.	Supplement the existing monitor well network for purpose of sampling shallow ground water.

Table 3.1-1. Tyndall AFB Phase II, Stage 2 Monitoring and Analysis (Continued, Page 4 of 5)

Site Description	Monitoring/Analysis Description	Rationale
Zone 9—POL Area B (continued)	Collect four ground water samples and analyze for:	
	Purgeable organics	Determine specific purgeable organics present at the site as a result of past fuel sludge burial activities.
	EDB	Indicator of AVGAS contamination.
	Petroleum hydrocarbons	Fuel sludges may have been disposed at zone.
	Lead	Leaded fuel sludge may have been disposed at zone.
Zone 10—"Shell Bank" Fire Training Area	Install three piezometers.	Define the hydraulic gradient in the shallow aquifer.
	Install one upgradient and two downgradient monitor wells.	Sample shallow ground water migrating under zone.
	Collect three ground water samples and analyze for:	
	Purgeable organics	Identify specific purgeable organics present as a result of past fire-training activities.
	Acid-extractable organics	Identify specific phenolic compounds which may have contaminated waste POL used during fire-training activities.
	Petroleum hydrocarbons	Waste POLs were used during fire-training activities and may have been spilled to grade.
	Lead	Leaded fuels may have been used during fire-training activities and allowed to spill to grade.

Table 3.1-1. Tyndall AFB Phase II, Stage 2 Monitoring and Analysis (Continued, Page 5 of 5)

Site Description	Monitoring/Analysis Description	Rationale
Zone 11—Active Fire Training Area	Install three piezometers.	Define the hydraulic gradient in the shallow aquifer.
	Install one upgradient and two downgradient monitor wells.	Sample shallow ground water migrating under zone.
	Collect three soil samples and analyze for:	
	Purgeable organics	Identify specific purgeable organics present in soil as a result of fire-training activities.
	Petroleum hydrocarbons	Waste POLs used during fire-training activities may have been released to grade.
	Lead	Leaded fuels may have been used during fire-training activities.
	Collect three ground water, two surface water, and two sediment samples and analyze for:	
	Purgeable organics.	Identify specific purgeable organics present in ground water, surface water, and sediments as a result of waste POLs.
	Acid-extractable organics	Identify specific phenolic compounds which may have been present in the waste POLs and during past fire-training activities.
	Petroleum hydrocarbons	Waste POLs have been used during fire-training activities.
	Lead	Leaded fuels may have been used during fire-training activities.

Sources: Thiess et al., 1984.
ESE, 1988.

upgradient and downgradient locations for additional monitor wells. New monitor wells were installed to supplement existing monitor wells installed during the Phase II, Stage 1 investigation. All monitor wells were screened in the shallow, unconfined aquifer. Boring logs, describing the subsurface geology at each site, were prepared during installation of the new monitor wells and are presented in Appendix F.

Surface water samples were collected at both Tyndall AFB (Zone 11) and Lynn Haven DFSP (Zone 2) to evaluate surface water contamination resulting from runoff and ground water discharge from potentially contaminated sites. Sediment samples were collected concurrently with each surface water sample and analyzed to evaluate the contamination of sediments by surface runoff from potentially contaminated sites.

Soil samples were collected in the vicinity of the active Fire Training Area (Zone 11) to determine if specific contaminants were present in surface and shallow soil horizons.

3.2 METHODOLOGY

3.2.1 GEOPHYSICAL SURVEY TECHNIQUES

A geophysical survey was conducted at the "6000" Area Landfill (Zone 8) using electromagnetic (EM) conductivity and magnetometry techniques. These instruments are used to determine the areal extent of disturbed soils, presence of buried metallic objects, and existence of leachate emanating from landfill areas into the shallow ground water table.

The principle of operation of the EM method consists of two coils and an electronics module. The transmitter coil is separated from the receiver coil by a specified distance. When energized, the transmitter coil induces circular eddy current loops into the earth. The magnitude of each current loop is a function of subsurface conditions. In turn, each of these current loops generates a secondary magnetic field which is proportional to the value of the current flowing within that loop. A portion of this secondary magnetic field is intercepted by the receiver coil and results in an output voltage which is amplified by the instrument. The magnitude of this voltage is linearly related to the terrain (ground) conductivity. The units of conductivity measurement are millimhos/meter (mmhos/m).

The depth of the EM survey is dependent upon various environmental factors (i.e., thickness of the subsurface layers, depth of the layers from the surface and the specific conductivities of each layer). The manufacturer suggests that the instrument is generally accurate to a depth of 6 meters. Based on the manufacturer's specifications, the depth of accuracy at this site was assumed to be approximately 6 meters.

The principal value of EM conductivity data is to provide continuous, high resolution data in an extremely economical manner. This permits reconnaissance investigations to be performed rapidly and effectively in defining the locations and extent of problem areas. EM methods have proven to be vital to geotechnical problems, geohydrological assessments, and environmental studies.

Magnetic field measurements can be used to locate buried ferromagnetic objects such as steel containers or drums, scrap iron, and tools. This method is based on the fact that an induced magnetism is produced in any magnetic material within the earth's magnetic field and, if sufficiently large, can be detected as an anomaly in the ambient field. Search magnetometers respond to changes in the earth's magnetic field caused by ferrous metals. Non-ferrous metals do not produce a magnetic response. The magnetometer indicates the presence of ferromagnetic objects by registering an audible signal (bleep) to the user.

Aerial photographs of the "6000" Area Landfill (Zone 8), taken in 1964 and made available to ESE by the Tyndall AFB Civil Engineering Squadron, indicated the areal size of the landfill was considerably more extensive than originally reported in the Phase II, Stage 1 report (Thiess et al., 1984). A ground reconnaissance of this area conducted during the Phase II, Stage 2 study determined debris was scattered across an irregularly shaped area with approximate dimensions of 500 ft x 800 ft. This ground reconnaissance also indicated that much of the area is currently densely vegetated, making a regularly spaced grid system for the geophysical survey difficult to develop. Therefore, an alternate survey method was selected where two semi-permanent stakes were posted, and survey transects were conducted through accessible areas with compass bearings observed and recorded for each transect. Terrain-conductivity measurements were recorded at 25-ft intervals, and areas with (elevated) anomalous conductivity values were scanned with the magnetometer to determine if buried ferromagnetic objects were the cause of the elevated readings. Results of the magnetometer survey are presented in Appendix G.

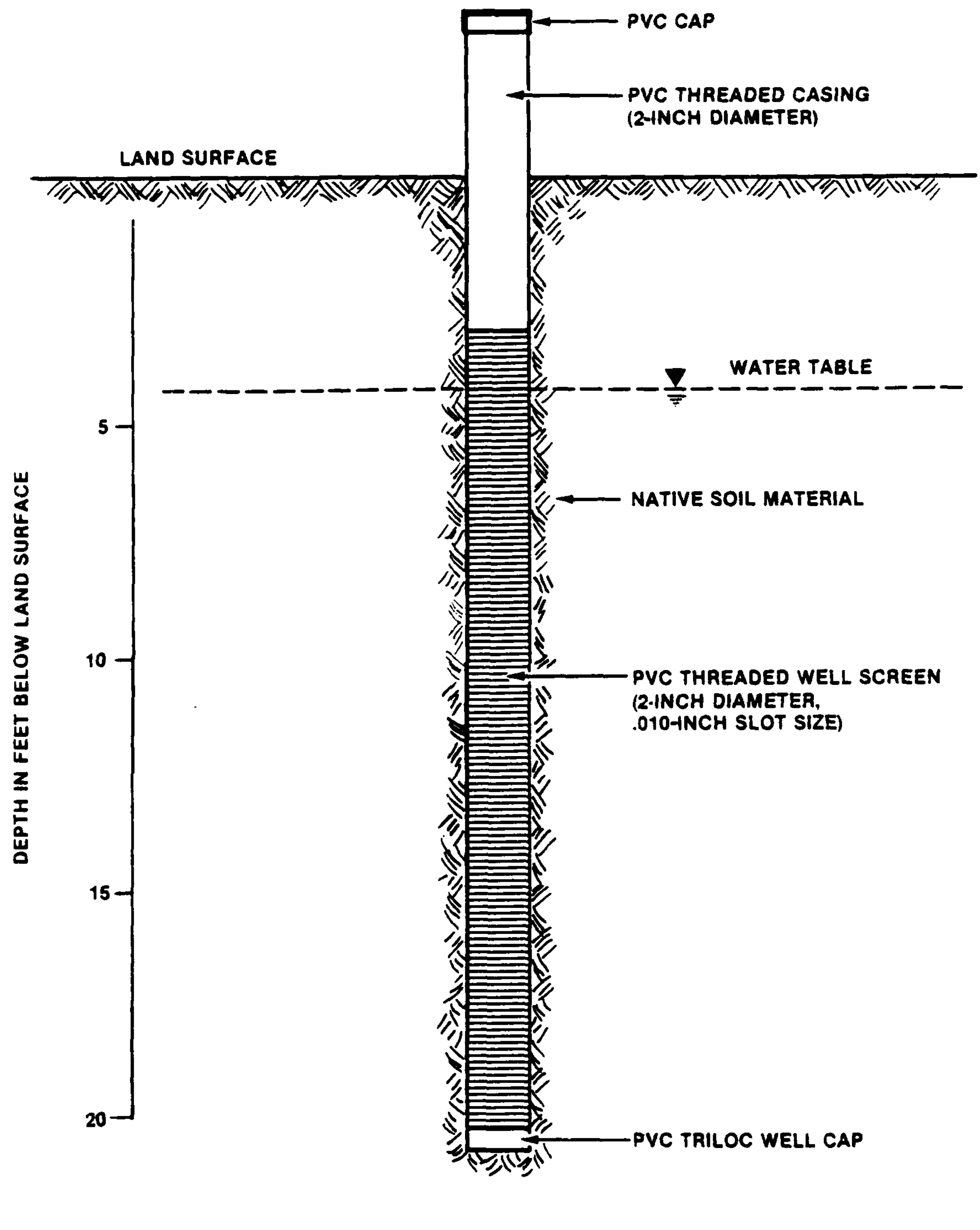
A total of 132 terrain-conductivity measurements were recorded across the site and analyzed in the field to assist in the placement of monitor wells. Upon completion of the field investigation, the results of the geophysical survey were entered into a data-processing and graphic-generating software package (Golden Graphics® System Version 2.0) at ESE's computer facilities in Gainesville. The results of this data

analysis are discussed in Sec. 3.3 and graphically and tabularly displayed in Appendix G.

3.2.2 PIEZOMETER INSTALLATION AND MONITORING

Eleven piezometers were installed at five zones at Tyndall AFB where additional water-level data were necessary to assure proper monitor well placement. The total footage installed was 147.4 ft, which consisted of 65.4 ft of solid casing and 82.0 ft of slotted screen. One piezometer was installed at Zone 9, two piezometers each were placed at Zones 6 and 8, and three piezometers each were placed at Zones 10 and 11. The numbering system utilized for piezometer designations is contained in Appendix H. The borings for all piezometers were completed using a Central Mine Equipment (CME) Model 55 drill rig. Several different techniques were used to install the piezometers. When subsurface conditions permitted, the piezometers were water-jetted into the ground with a high-pressure hose using approved water obtained from the Bay County Municipal Water system and stored on the CME-55 rig. Analytical results of the water provided by the Bay County Water Department are presented in Appendix I. Analysis of Bay County Municipal Water showed all base-neutral and acid extractable organics to be below analytical detection limits. All purgeable organics were below analytical detection limits with the exception of trace levels of chloroform and bromodichloromethane. All metals were well below their respective primary and secondary drinking water standards. Whenever shells or hard substrate materials were encountered, the borehole was opened by wash-rotary or solid-stem augering techniques, and the piezometers inserted into the borehole following removal of the drill stem. Total depth of the borehole varied from site to site, depending on local water-table conditions, and ranged from 10.3 to 18.0 ft. Screened intervals, cased intervals, and total length of piezometers are summarized in Appendix J.

The piezometers were constructed of threaded, Schedule 40 polyvinyl chloride (PVC) well pipe with 5 to 10 ft of 0.010-inch slotted screen with an inside diameter of 2 inches (see Fig. 3.2-1). The bottom of the screen was capped prior to installation, and a vented cap fitted at the top of each piezometer. Filter packs, bentonite seals, and grout seals



SOURCE: ESE, 1988.

Figure 3.2-1 **TYPICAL CONSTRUCTION DETAIL—PIEZOMETERS**	**INSTALLATION RESTORATION PROGRAM** **Tyndall Air Force Base**

were not used in piezometer construction. When necessary, drill cuttings were backfilled around the screen and casing in the borehole.

At each piezometer site, installation was completed immediately following the termination of drilling, or occurred simultaneously at the sites where the water-jetting method was used. The screen and casing were carefully cleaned with approved water prior to installation. The solid casing extended from the top of the screen to approximately 2.0 ft above the land surface.

Water-level measurements were obtained from the piezometers no sooner than 48 hours after completion, allowing the water table to reach equilibrium. Water-level measurements were obtained using the U.S. Geological Survey (USGS) wetted-tape method, which is accurate to 0.01 ft. The tape was rinsed with water from the approved source, wiped with a clean cloth, and allowed to air dry between consecutive water-level measurements. At each zone, static water-level measurements were obtained in all piezometers within a 1-hour period to ensure consistency between all measurements.

The vertical elevations of all the piezometers were surveyed by a certified surveyor registered in the State of Florida. The survey results for piezometer elevations, water-level measurements, and water-table elevations relative to mean sea level are provided in Appendix J.

All piezometers were removed at completion of the field investigation, and boreholes were grouted to the surface wherever necessary.

3.2.3 MONITOR WELL INSTALLATION AND MONITORING

Seventeen 4-inch-diameter ground water monitoring wells were installed at six zones at Tyndall AFB and Lynn Haven DFSP. Total footage installed was 373.5 ft, consisting of 118.5 ft of casing and 255.0 ft of slotted screen. Two monitor wells each were installed at Zones 2, 6, 8, and 9; three monitor wells each were installed at Zones 3, 10, and 11. Appendix F contains details of monitor well construction, and Appendix H

describes the numbering systems utilized for monitor well and ground water sample designations.

Borings for all ground water monitor wells were completed using a CME Model 55 drill rig equipped with hollow-stem augers with a 6-inch inside diameter and 10.5-inch outside diameter. All wells were installed using hollow-stem augering techniques in accordance with American Society for Testing and Materials (ASTM) D-1452 procedures. Drilling was performed without the use of water, and the bottom of the auger was covered with a retrievable plug when required by subsurface conditions ("running sand" was encountered when augering below the water table in fine grain sand). Four-inch PVC well pipe and screen were installed through the center of the hollow drill stem and positioned at the appropriate depths. As the auger was withdrawn from the hole, the annular space between the well casing and the drill stem was backfilled with clean silica sand. This technique prevented collapse of the borehole that could have occurred had the auger been removed prior to the introduction of the well pipe.

Lithologic logging was performed during monitor well construction using a standard split-spoon sampler in general accordance with ASTM D-1586 procedures. Samples were obtained from the ground surface to the top of the water table at each boring site. Because "running sand" necessitated the use of the retrievable plug at the bottom of the hollow-stem augers, split-spoon samples below the water table could not be obtained. Descriptions of split-spoon samples included the Unified Soil Classification System (USCS) classification, soil composition, grading, color, plasticity, consistency and/or density, and moisture content. Other observations, such as bedding texture or depositional environments, were noted when determinable. Standard penetration tests were conducted, with results recorded as blows per foot on the driller's logs. Lithologic descriptions for the sediments encountered below the water table were performed by the ESE Site Geologist from drill cuttings. The split-spoon sampler was cleaned with water from the approved source between each sample (i.e., each time a sample was removed from the tube). Lithologic descriptions of all monitor well boreholes are included in Appendix F.

All split-spoon soil samples and drill cuttings were screened with an HNU vapor analyzer. The HNU is an organic vapor analyzer that uses a photoionization detector. The sensor consists of a sealed ultraviolet (UV) light source that emits photons which are energetic enough to ionize many trace organics but not the major components of air such as oxygen (O_2), nitrogen (N_2), carbon monoxide (CO), carbon dioxide (CO_2), or water (H_2O). A chamber adjacent to the UV source contains a pair of electrodes. When a positive potential is applied to one electrode, the field created drives ions, formed by absorption of UV light, to the collector electrode. The current measured is proportional to the concentration of organic vapors. The useful range of the instrument is from <1 to about 2,000 parts per million (ppm). Cuttings from two boreholes at POL Area B (Zone 9) and one borehole at the U.S. Highway 98 fire-training area (Zone 6) had elevated concentrations of organic vapors; therefore, they were containerized into 55-gal drums and removed from the site by the base Civil Engineering Squadron. Samples of the cuttings were analyzed for extraction procedure (EP) toxicity and found to be below the threshold to be classified as a hazardous waste.

The total depths and placement of monitor wells and the location of screened intervals are discussed for each zone in Section 3.3. Typical monitor well construction is shown in Fig. 3.2-2.

Monitor wells were finished in the shallow, unconfined aquifer and were typically 20 ft deep. The wells were constructed of threaded Schedule 40 PVC pipe, with 0.010-inch slotted screen in the bottom 15-ft interval. A filter pack, approximately 16 ft thick, was placed in the annular space between the screen and the borehole, a bentonite clay seal on the top of the filter pack, and grout in the upper annular space to the surface. Well bottoms were capped before the screens were installed, and vented caps were installed at the top of all monitor wells. Protective steel casings and locking caps were installed over the risers for security.

When the screened interval consisted of clean sand or gravel, the formation occasionally collapsed around the lower portion of the screen, with filter material added above the cave-in to the appropriate depth.

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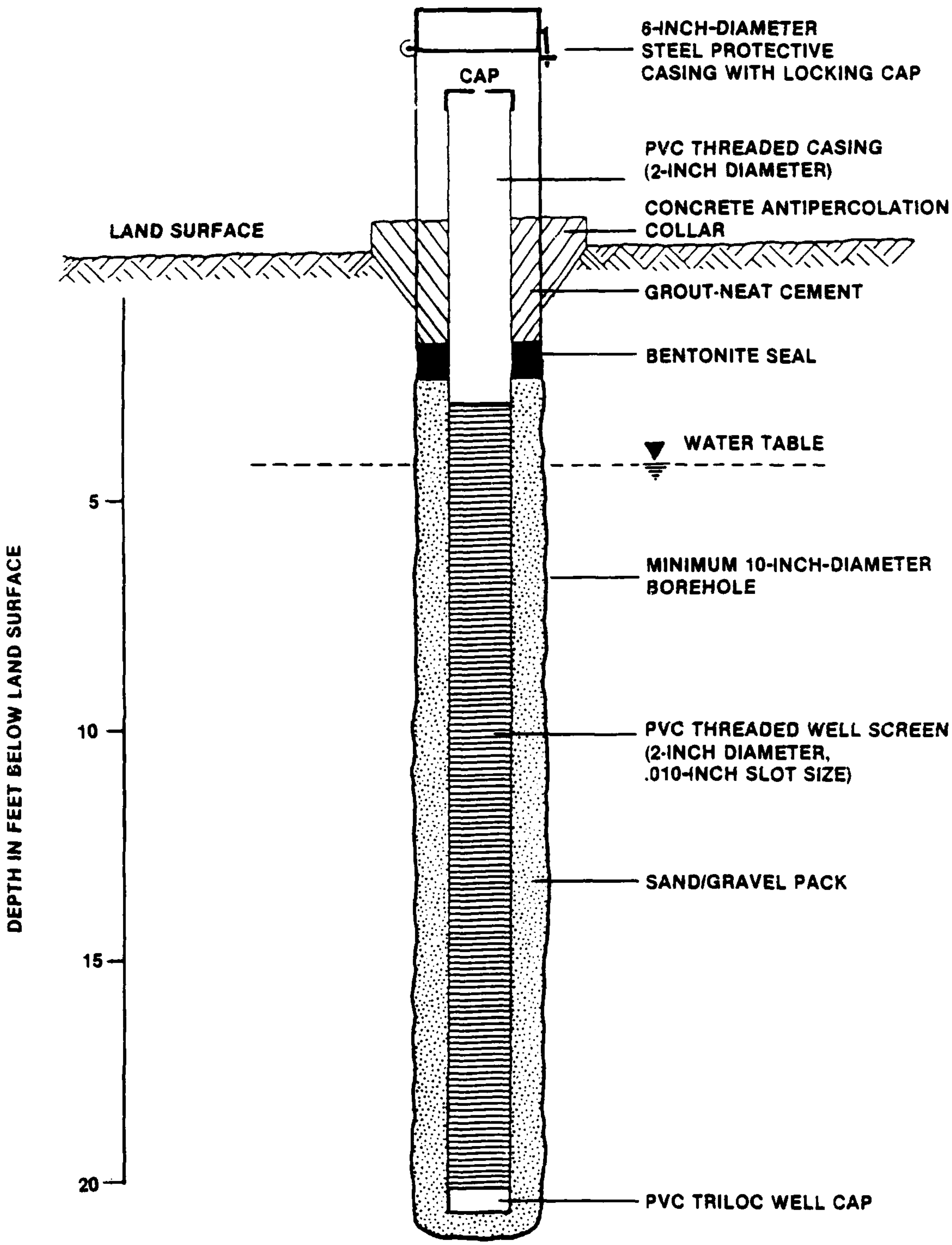

SOURCE: ESE, 1988.

Figure 3.2-2 **TYPICAL CONSTRUCTION DETAIL—** **MONITOR WELLS**	**INSTALLATION RESTORATION PROGRAM** **Tyndall Air Force Base**

If not, filter material was installed around the entire length of the well screen. Small amounts of approved water were added, as necessary, to assure that the bentonite pellets expanded to form a tight seal.

The bentonite-cement grout seal extended from the top of the bentonite plug to the ground surface. Grouting was performed in the presence of the ESE Site Geologist. The aboveground protective casing was sealed in the grout. Identifying marks were inscribed on the casing, and protective steel posts were installed around the well. A concrete antipercolation collar, approximately 4 ft x 4 ft, was poured on the ground surface at each monitor well.

The following materials were used in monitor well construction.

1. Casing used in the well was threaded PVC Schedule 40, 4-inch nominal inside diameter. The well screen was factory slotted, with a slot width of 0.010 inch. An oversized vented slip-on cap or a screw-on cap was installed on each well.
2. The grout mixture was 10 parts Portland® cement to one-half part bentonite (by weight), with a maximum of 10 gal of approved water per 94-pound (lb) bag of cement. Bentonite was added after mixing the cement and water. After the grout seal had set (approximately 24 hours), it was checked for settlement, and additional grout (of similar composition) was added to fill any depressions whenever necessary.
3. Commercially available bentonite pellets manufactured specifically for well-sealing purposes were used in the seal. Pellets were allowed to hydrate prior to pouring grout.
4. Sand used in the filter envelope around the well screen was selected for compatibility with the screen slot size and aquifer materials.
5. A 6-inch protective steel casing was installed around all wells. This casing extended approximately 2.5 to 3.5 ft above land surface and was seated 1.5 to 2.5 ft into the well seal grout. This casing was vented to the atmosphere via a lockable, hinged cap. This cap prevents entry of water but is not airtight. In this manner, the well is in open connection to the atmosphere to

allow for water-level stabilization due to natural fluctuations in barometric pressure. All monitor wells were locked using the same key.

Before borings were drilled for installation of the piezometers and monitor wells, the ESE Site Geologist reviewed the proposed drilling locations with the Tyndall AFB Civil Engineering Squadron to avoid drilling into buried utilities such as cables or pipes. Based on this review, Tyndall AFB Civil Engineering approved all locations and issued appropriate drilling permits. The ESE Site Geologist supervised the drilling and installation of all piezometers and monitor wells, maintained drilling logs, and observed soil samples for lithological descriptions and potential evidence of contamination.

Drilling was performed by ESE drillers under the supervision of the ESE Site Geologist. In addition to drilling of the boreholes, the drillers were responsible for the following requirements:

1. Arrangement of access to all sites where drilling was proposed;
2. Steam cleaning of all down hole drilling equipment before entrance to Tyndall AFB.
3. Arrangement for both onbase and offbase storage of all well drilling equipment and well installation supplies in a clean and secure area; clean, unused equipment and supplies were temporarily stored on sheets of disposable polyethylene at each drilling location to eliminate contamination from the native soils;
4. Obtaining approved Bay County water for drilling and well installation;
5. Containerization of any drill cuttings deemed contaminated by the ESE Site Geologist; and
6. Cleaning of drilling tools between borings with approved Bay County water to remove all traces of soil, rock, or other potential contaminants.

The ESE Site Geologist maintained drilling logs in a field notebook for all boreholes. The logs comprised a record of soil characteristics,

lithology, sequence of events during well construction, and personnel. Each boring was logged in the field notebook as it was being drilled. The following data were recorded in the boring logs:

1. Depths, recorded in feet;
2. Soil descriptions prepared in the field by the ESE Site Geologist in accordance with USCS;
3. Descriptions of split-spoon samples and cuttings, including:
   a Classification:
   b. Secondary components and estimated percentage;
   c. Color;
   d. Plasticity;
   e. Consistency (cohesive soil) or density (noncohesive soil);
   f. Moisture content; and
   g. Texture, fabric, and bedding.
4. Length of sample recovered in each sampled interval for split-spoon samples;
5. Blow counts, hammer weight, interval, and length of fall for split-spoon samples;
6. Depth to water first encountered during drilling;
7. Type of drilling equipment used, including rod size, bit type, driller, and types of materials used for well construction;
8. Drilling sequence;
9. Special problems;
10. Start and completion dates of all borings; and
11. Well construction diagrams.

All well logs, construction diagrams, and description of activities at each borehole site are provided in Appendix F.

Wells were developed by inserting a 1-inch-diameter Schedule 20 PVC downpipe inside the well, extending from the bottom of the well to the top of the casing. The PVC downpipe was attached to a centrifugal pump. Water was pumped either continuously or discontinuously from the well, depending upon the productive capabilities of the well. No water was added to the wells during development. Prior to use, the downpipes were decontaminated by means of a soap-water wash, deionized-water rinse, and

a methanol rinse (which was allowed to air dry). Each well had a separate dedicated downpipe. The centrifugal pump was thoroughly rinsed using approved water prior to use at the next well. Well development data were recorded in the field in a tabular format and included the following:

1. Well identification;
2. Date and time development originated;
3. Boring and well casing diameter;
4. Annular space length;
5. Riser stickup length;
6. Static water level prior to development;
7. Total length of well casing;
8. Length of column of water in the well;
9. Quantity of standing water in well and annulus (30-percent porosity assumed for calculation) prior to development;
10. Specific conductivity, temperature, and pH measurements were taken and recorded at the start, mid-point, and conclusion of development. Calibration standards were run prior to and after each day's operation in the field.
11. Physical character of removed water, including changes during development in clarity, color, particulates, and odor;
12. Production characteristics of the well (i.e., continuous versus discontinuous pumping, gallons per minute); and
13. Quantity of water removed during development.

Prior to development, wells were allowed to equilibrate for at least 48 hours after completion of installation. Each well was developed until the following conditions were met:

1. The well water was clear to the unaided eye;
2. The sediment thickness remaining in the well was less than 5 percent of the screen length (generally no sediment remained inside the casing); and
3. A volume of water was removed from the well equal to at least five well volumes, including the saturated filter material in the annulus.

All water-level measurements at monitor wells were obtained using the USGS wetted-tape method. The tape was rinsed with water from the approved source, wiped with a fresh cloth, and allowed to air dry between consecutive water-level measurements. At least one complete set of static water-level measurements for all accessible wells at Tyndall AFB was made over a single, consecutive 10-hour period, with wells at Lynn Haven DFSP measured under similar conditions on a separate day. A summary of monitor well water-level measurements is provided in Appendix K.

Each monitor well was surveyed by a certified state-registered land surveyor, to establish map coordinates and elevation. Horizontal map coordinates were referenced to the Universal Transverse Mercator (UTM) Grid System with an accuracy no less than 1:10,000 (one in ten thousand). Elevations for the top of the PVC casing of each monitor well were determined to within 0.01 ft accuracy using the vertical datum established by USGS, whereas natural ground surface elevations at each site were determined to within 0.1 ft accuracy. The elevation (top of the PVC casing) and map coordinates for each monitor well were plotted on the Tyndall AFB base map (Appendix L).

Ground water sampling was initiated after the new monitor wells had been allowed to reach equilibrium (no less than 5 days after well development). The following procedures were performed during sampling:

1. The depth to water was measured from the top of casing.
2. The well depth was sounded and recorded. The volume of water in the well was calculated.
3. Typically, five volumes of water in the screen, well casing, and saturated annulus were purged by pumping or bailing before sampling. Fine-grained sediments at some of the well locations caused slow recharge rates. In such cases, reduction of well purging to less than five volumes was implemented when excessive time would have elapsed attempting to collect one or two samples from low-yielding wells. The amount of fluid purged was measured and recorded.

4. Sampling was accomplished by a bailer constructed of inert materials (Teflon®). No glue was used in the construction of these bailers.
5. To protect the wells from contamination during sampling procedures, the following guidelines were followed:
   a. The bailer was thoroughly decontaminated prior to use at each well location, using a soap-water wash, deionized-water rinse, and a methanol rinse procedure. Bailers were allowed to air dry prior to sampling.
   b. When a pump was used to purge the standing water from the well, the pump and hose were thoroughly decontaminated between the samples.
   c. All sampling equipment was protected from ground contact by polyethylene plastic sheeting to prevent soil contamination from tainting the ground water samples. Disposable rubber gloves were worn during ground water sampling and changed between wells.
   d. After purging, each monitor well was sampled as soon as sufficient water returned to minimize the contact time between the water sample and the well casing.
6. Conductivity, pH, and temperature were measured before sampling.

The following data were recorded in the field logbook for each monitor well:

1. Well identification;
2. Date;
3. Time sampling originated;
4. Boring and well casing diameter;
5. Annular space length;
6. Riser stickup length;
7. Static water level prior to purging;
8. Total length of well casing;
9. Length of column of water in well;

10. Quantity of standing water in well and annulus (30-percent porosity assumed for calculation) prior to purging;
11. Specific conductivity, temperature, and pH measurements were taken and recorded at the start, mid-point, and conclusion of purging. Calibration standards were run prior to and after each day's operation in the field;
12. Physical character of removed water, including changes during purging in clarity, color, particulates, and odor;
13. Quantity of water removed during purging;
14. Time of sampling;
15. Computer-generated sample number listed on sample container label;
16. Miscellaneous observations (i.e., QA sample set taken and sample selected for shipment to Brooks AFB); and
17. Signature of sampler and date signed.

Ground water sample logs are provided in Appendix M.

Each sample was labeled for identification by laboratory personnel. The sample label included the project number, a unique sample number, time and date sampled, and sampler's initials. All samples were identified with non-water-soluble ink on ESE's standard preprinted and prenumbered labels immediately after collection. Information concerning preservation methods, sample matrix, and sample location number was included on the labels. Samples were shipped to ESE's Gainesville laboratories via Federal Express in coolers, and were chilled to approximately 4 degrees Celsius (°C) from time of sample collection until analysis. Chain-of-custody documentation was maintained from the time of sample collection to analysis. A discussion of the ground water sample numbering system is included in Appendix H.

3.2.4 SURFACE WATER SAMPLING

Prior to the collection of surface water samples, the following site-specific information was recorded in the field notebook:

1. Site number or location;
2. Date;
3. Time (24-hour system);
4. Antecedent weather conditions, if known;
5. In situ parameter measurements (temperature, conductivity, and pH);
6. Fractions and preservatives;
7. Any other pertinent observations (e.g., visible contamination); and
8. Signature of sampler and date signed.

Surface water sample logs are included in Appendix N.

At the conclusion of each workday onsite, the Sampling Team Leader reviewed each page of the notebook for errors and omissions before dating and signing each reviewed page. All field instrument calibrations were recorded in a designated portion of the notebook at the time of the calibration. Instruments were calibrated at least twice daily.

Each surface water sample was collected in a manner that minimized aeration and prevented oxidation of reduced compounds in the sample. Due to the depth of the surface water at the sampling sites at Zones 2 and 11 (6 to 9 inches), samples were obtained using a noncontaminating sampling bottle from a depth just below the water surface. The containers were filled until overflowing, except for fractions with preservatives, and caution was taken to avoid air bubbles. Sample containers were tightly capped.

Each sample was labeled for identification by laboratory personnel. The sample label included the project number, a unique sample number, time and date sampled, and sampler's initials. All samples were identified with non-water-soluble ink on ESE's standard preprinted and prenumbered labels immediately after collection. Information concerning preservation methods, sample matrix, and sample location number was included on the labels. Samples were shipped in coolers and chilled to aproximately 4°C from time of sample collection until analysis. A record of chain-of-custody was maintained from sampling to analysis. A description of the surface water sample numbering system is included in Appendix H.

3.2.5 SEDIMENT SAMPLING

Prior to the collection of sediment samples, the following site-specific information was recorded in the field notebook:

1. Site number and location,
2. Sample number,
3. Date sample was collected,
4. Field personnel,
5. Sampling method used,
6. Time of sampling,
7. Depth to sediment,
8. Sediment type,
9. Fractions and preservatives,
10. Any other pertinent observations, and
11. Signature of sampler and date signed.

Sediment sample logs are included in Appendix N.

Sediment samples were collected using a 2-inch-diameter coring tube made of noncontaminating plastic. Coring tubes were hand driven into the sediment to a depth of approximately 6 inches. Each sample was labeled for identification by laboratory personnel. The sample label included the project number, a unique sample number, time and date sampled, and

sampler's initials. All samples were identified with non-water-soluble ink on ESE's standard preprinted and prenumbered labels immediately after collection. Information concerning preservation methods, sample matrix, and sample location number was included on the labels. Samples were shipped in coolers and chilled to approximately 4°C from the time of sample collection until analysis. Chain-of-custody documentation was maintained from sample collection through analysis. A description of the sediment sample numbering system is included in Appendix H.

3.2.6 SOIL BORING AND SAMPLING

Prior to and during the collection of soil samples, the following site-specific information was recorded on soil boring logs:

1. Site number and location,
2. Date sample was collected,
3. Sample number,
4. Driller,
5. Boring method,
6. Boring diameter,
7. Time sample was collected,
8. Depth of sample,
9. Lithologic description of soil,
10. Standard penetration test results,
11. Boring sequence,
12. Fractions sampled,
13. Any other pertinent observations, and
14. Signature of sampler and date signed.

Soil samples were collected using split-spoon samplers, and samples were collected continuously from the land surface to a depth of 10 ft. Samples were collected using a hand-held, stainless-steel sampler to "scoop" the soil from the split spoon and place it in wide-mouth glass jars lined with Teflon® lids, therefore minimizing any handling of the

sample. The hand-held sampler and the split-spoon sampler were decontaminated following each sample using the soap-water wash, deionized water rinse, and methanol rinse method previously described. All sampling equipment was allowed to air dry prior to the collection of the next sample. All sampling equipment was protected from ground contact by disposable polyethylene plastic sheeting.

Split-spoon samples from all intervals of the borehole were described for lithologic characteristics using the same method described in Sec. 3.2.4. All soil boring logs are provided in Appendix N.

Soil samples were collected in a manner that minimized aeration and prevented oxidation of reduced compounds in the sample. Each sample was labeled for identification by laboratory personnel. The sample label included the project number, a unique sample number, time and date sampled, and sampler's initials. All samples were identified with non-water-soluble ink on ESE's standard preprinted and prenumbered labels immediately after collection. Information concerning preservation methods, sample matrix, and sample location number was included on the labels. Samples were shipped in coolers and chilled to approximately 4°C from the time of sample collection until analysis. Chain-of-custody documentation was maintained from the time of sampling until final analysis. A description of the soil sample number system is included in Appendix H.

3.3 IMPLEMENTATION OF THE FIELD PROGRAM

Field work completed at each of the nine zones on Tyndall AFB is described. Zone 2 is located at Lynn Haven DFSP Facility in Lynn Haven, Florida, approximately 12 miles northwest of Tyndall AFB. Ground water quality was investigated through the installation and sampling of 17 monitor wells, in addition to sampling 21 existing monitor wells at all nine zones; sediment and surface water samples were collected at Zone 11 on Tyndall AFB and Zone 2 on Lynn Haven DFSP. In addition, potential soil contamination was investigated at Zone 11 on Tyndall AFB. Construction and water-level data for all piezometers installed at the various zones as part of this study are included in Appendix J.

New monitor wells were developed as described in Sec. 3.2.3 of this report. Details of the development effort are available in Appendix O. All new monitor well elevations and horizontal coordinates were determined by a licensed surveyor according to the procedures described in Section 3.2.3 of this report. Details of the surveyor's results are provided in Appendix K. Individual borehole lithologies for the 17 new wells are described in detail in the monitor well drilling logs in Appendix F. Lithologic descriptions of the 21 pre-existing wells are available in the Phase II, Stage 1 report (Thiess et al., 1984). Boring descriptions from all 38 monitor wells sampled during the Phase II, Stage 2 study were used to evaluate the subsurface geology at each site. Water-level measurements and well-yield rates obtained during well development and/or purging were used to assess the hydrogeologic characteristics at each site. All sampling was performed in accordance with approved QA procedures.

3.3.1 ZONE 2--LYNN HAVEN DFSP

The Lynn Haven DFSP is a bulk fuels storage/dispensing terminal located adjacent to North Bay (Fig. 3.3-1) in Lynn Haven, Florida.

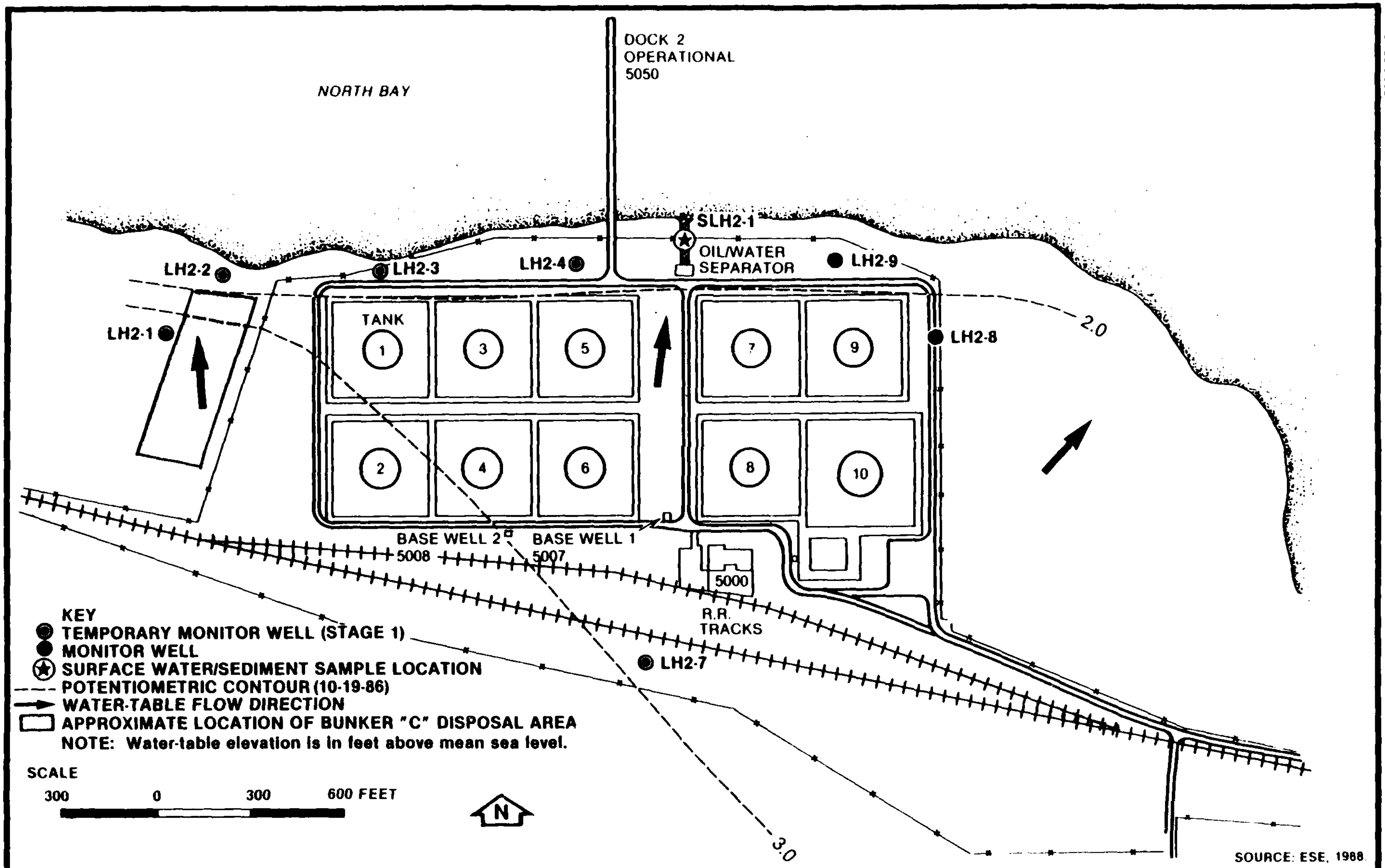

Figure 3.3-1
SITE MAP FOR ZONE 2 — LYNN HAVEN DFSP

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The objectives of the investigations at Zone 2 were to:

1. Determine if the surface drainage ditch adjacent to the oil/water separator was transporting contaminants from the petroleum storage tank area to North Bay;
2. Identify specific contaminants, if present, which are being released into the surface waters or sediments of North Bay;
3. Identify specific contaminants which may be present in the shallow surficial aquifer underlying the site;
4. Determine if hydrogeologic conditions in the area underlying and adjacent to the site are conducive to contaminant migration; and
5. Determine, if present in the ground water, whether these specific contaminants are migrating downgradient from the area.

Sediment and surface water samples were collected from the centerline of the oil/water separator drainage ditch near the northeast corner of the facility (Fig. 3.3-1). These samples were collected to evaluate the quality of surface water drainage from the oil/water separator discharging into North Bay.

Two downgradient monitor wells (LH2-8 and LH2-9) were installed at Zone 2 to replace damaged wells which were originally installed during the Phase II, Stage 1 study. The damaged wells were grouted to the surface using a bentonite-cement mix. The locations of the two new monitor wells, in addition to five Phase II, Stage 1 monitor wells, are shown in Fig. 3.3-1. Monitor well depths, screened intervals, lithology of the screened intervals, elevation of ground surface, and elevation of water table are given in Table 3.3-1 for wells installed as part of the Phase II investigations. A total of seven monitor wells (two new monitor wells and five existing Stage 1 temporary wells) were sampled to evaluate the quality of the shallow ground water in the vicinity and to determine if contaminants were migrating from the site. The samples were analyzed for purgeable organics, petroleum hydrocarbons, and lead.

Table 3.3-1. Zone 2 Monitor Well Construction Data and Water Levels

Monitor Well Designation	Depth (ft)	Screened Interval†	Lithology of Screened Interval	Elevation of Ground Surface*	Water-Table Elevation*
LH2-1**	13.3	0.8 to 12.8	Sand, trace silt	7.9	3.7 (10/22/86)
LH2-2**	13.3	0.8 to 12.8	Sand, trace to 10% silt	4.3	1.9 (10/22/86)
LH2-3**	13.3	0.8 to 12.8	Sand, trace to 30% silt	3.9	1.5 (10/22/86)
LH2-4**	13.3	0.8 to 12.8	Sand, trace to 5% silt	5.1	1.8 (10/22/86)
LH2-7**	12.0	0.8 to 12.0	Sand, trace silt	7.1	2.9 (10/22/86)
LH2-8	19.0	3.5 to 18.5	Sand, trace to 25% silt	6.6	2.68 (10/22/86)
LH2-9	19.0	3.5 to 18.5	Sand, trace to 25% silt	4.5	1.60 (10/22/86)

*All elevations in feet above mean sea level.
†Screened interval in feet below ground level.
**Monitor wells installed during Phase II, Stage 1.

Sources: Thiess et al., 1984.
ESE, 1988.

3.3.2 ZONE 3--POL AREA A

POL Area A is a tank farm located near the Shoal Point Bayou barge unloading facilities on Tyndall AFB (Fig. 3.3-2).

The objectives of the investigation at Zone 3 were to:

1. Identify specific contaminants which may be present in the shallow surficial aquifer underlying the site;
2. Determine if hydrogeologic conditions in the area underlying and adjacent to the site are conducive to contaminant migration; and
3. Determine, if present in the ground water, whether these specific contaminants are migrating from the area.

One upgradient monitor well (T3-7) and two downgradient monitor wells (T3-5 and T3-6) were installed at Zone 3 to supplement four existing monitor wells. Water-table-gradient data at the site indicated the four existing Stage 1 temporary monitor wells were placed outside of or oblique to the potential contaminant migration path. The locations of all seven monitor wells are depicted in Fig. 3.3-2. Monitor well depths, screened intervals, lithology of the screened intervals, elevation of the ground surface, and elevation of the water table are given in Table 3.3-2. The seven monitor wells were sampled to evaluate the quality of the shallow ground water in the vicinity and to determine if contaminants were migrating from the site. The samples were analyzed for EDB, petroleum hydrocarbons, and lead.

3.3.3 ZONE 5--SMALL ARMS REPAIR AREA

Zone 5, located in an open field in the "6000" Area (Fig. 3.3-3), may have served as a disposal area for waste paints and solvents between 1965 and 1972.

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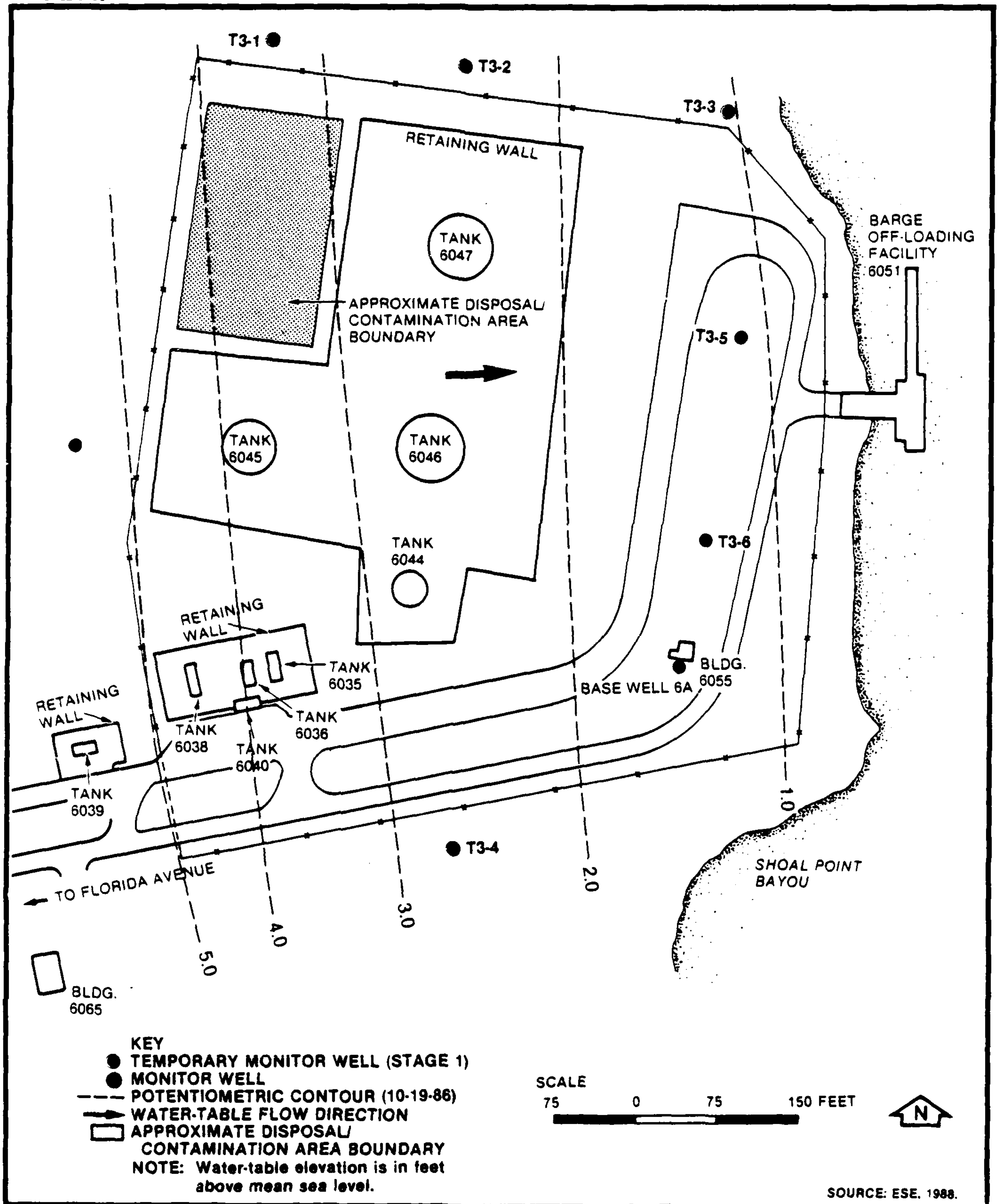

Figure 3.3-2
SITE MAP FOR ZONE 3 —
POL AREA A

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Table 3.3-2. Zone 3 Monitor Well Construction Data and Water Levels

Monitor Well Designation	Depth (ft)	Screened Interval†	Lithology of Screened Interval	Elevation of Ground Surface*	Water-Table Elevation*
T3-1**	10.3	1.0 to 9.8	Sand, trace silt	8.2	3.2 (10/14/86)
T3-2**	10.3	1.0 to 9.8	Sand, trace silt	6.2	2.4 (10/19/86)
T3-3**	9.3	1.0 to 8.5	Sand, trace silt to 5% silt	2.1	1.0 (10/19/86)
T3-4**	10.3	2.0 to 9.5	Sand, 5 to 10% silt	5.1	2.7 (10/19/86)
T3-5	18.5	3.0 to 18.0	Sand, 10% silt	5.0	1.18 (10/17/86)
T3-6	19.0	3.5 to 18.5	Sand	5.8	1.33 (10/17/86)
T3-7	19.5	4.0 to 19.0	Sand, 10 to 15% silt	9.6	5.59 (10/19/86)

*All elevations in feet above mean sea level.
†Screened interval in feet below ground level.
**Monitor wells installed during Phase II, Stage 1.

Sources: Thiess *et al.*, 1984.
ESE, 1988.

TYNDALL 2/89E

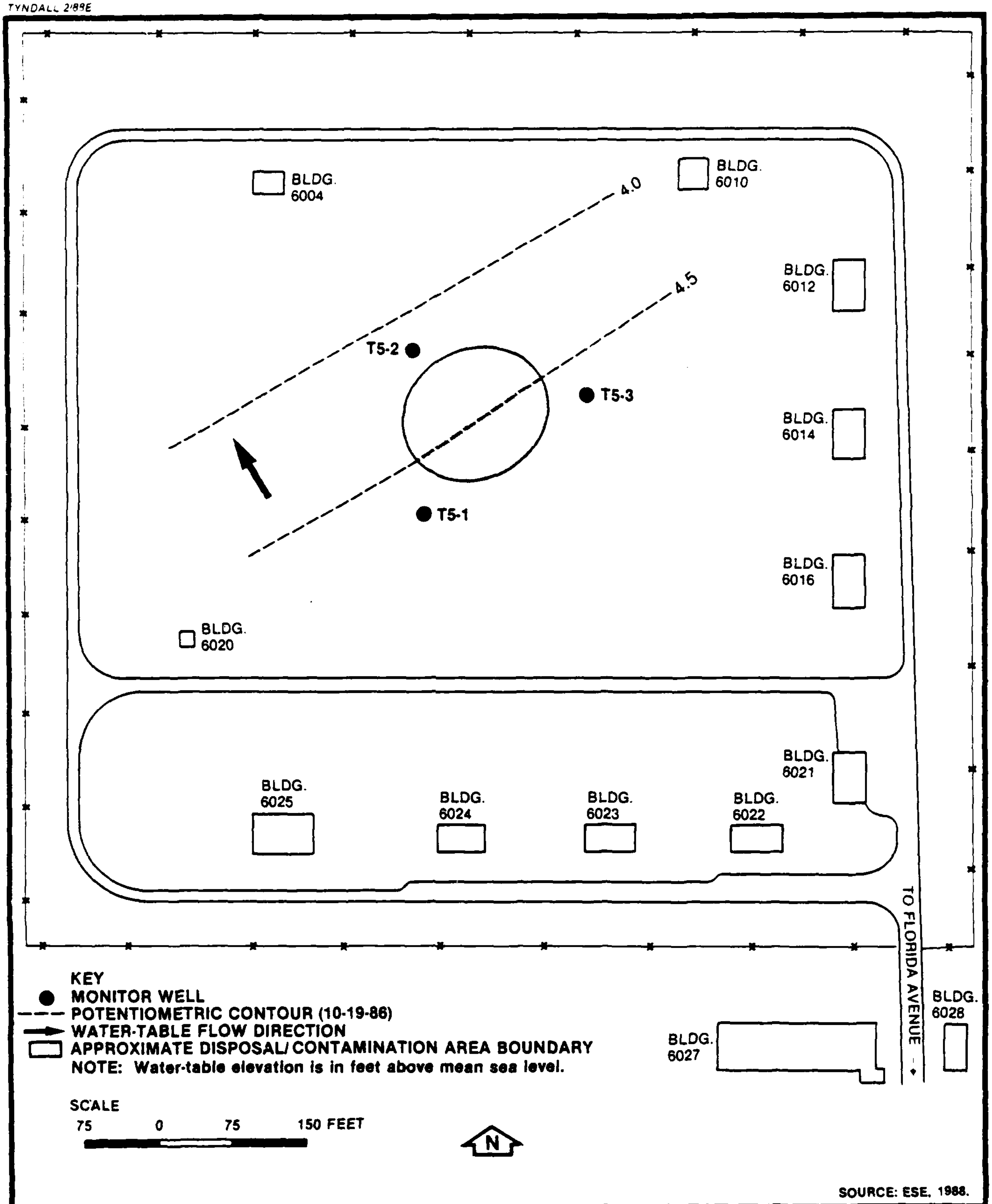

Figure 3.3-3
SITE MAP FOR ZONE 5 —
SMALL ARMS REPAIR AREA

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Objectives of the investigations at Zone 5 were to:

1. Identify specific contaminants which may be present in the shallow surficial aquifer underlying the site; and
2. Determine, if present in the ground water, whether these specific contaminants were migrating downgradient from the area.

The three existing monitor wells at Zone 5 were considered sufficient to characterize the ground water at the site; therefore, no new monitor wells were installed. The locations of the three monitor wells are depicted in Fig. 3.3-3. Monitor well depths, screened intervals, lithology of the screened intervals, elevation of the ground surface, and elevation of the water table are given in Table 3.3-3.

The three monitor wells were sampled to evaluate the quality of the shallow ground water in the vicinity and to determine if contaminants were migrating from the site. The samples were analyzed for purgeable organics, acid-extractable organics, and priority pollutant metals.

Research into the types of processes used in the Small Arms Repair Area (blueing and parkerizing) revealed the potential existed for selenium contamination at the site.

3.3.4 ZONE 6--HIGHWAY 98 FIRE TRAINING AREA

Zone 6 served as a fire-training area from 1952 to 1968. This area was also a repository for POL waste stored in 20,000-gal tanks and may have been a burial site for empty drums on Tyndall AFB (Fig. 3.3-4).

Objectives of the investigations at Zone 6 were to:

1. Define the hydraulic gradient in the shallow aquifer system;
2. Identify specific contaminants which may be present in the shallow surficial aquifer underlying the site;

Table 3.3-3. Zone 5 Monitor Well Construction Data and Water Levels

Monitor Well Designation	Depth (ft)	Screened Interval†	Lithology of Screened Interval	Elevation of Ground Surface*	Water-Table Elevation*
T5-1**	15.3	5.5 to 14.5	Sand, trace to 15% silt	10.9	4.6 (10/19/86)
T5-2**	15.3	5.5 to 14.5	Sand, trace to 10% silt	10.7	4.1 (10/19/86)
T5-3**	15.3	5.5 to 14.5	Sand, trace to 5% silt	9.9	4.6 (10/19/86)

*All elevations in feet above mean sea level.
†Screened interval in feet below ground level.
**All Zone 5 monitor wells installed during Phase II, Stage 1.

Sources: Thiess et al., 1984.
ESE, 1988.

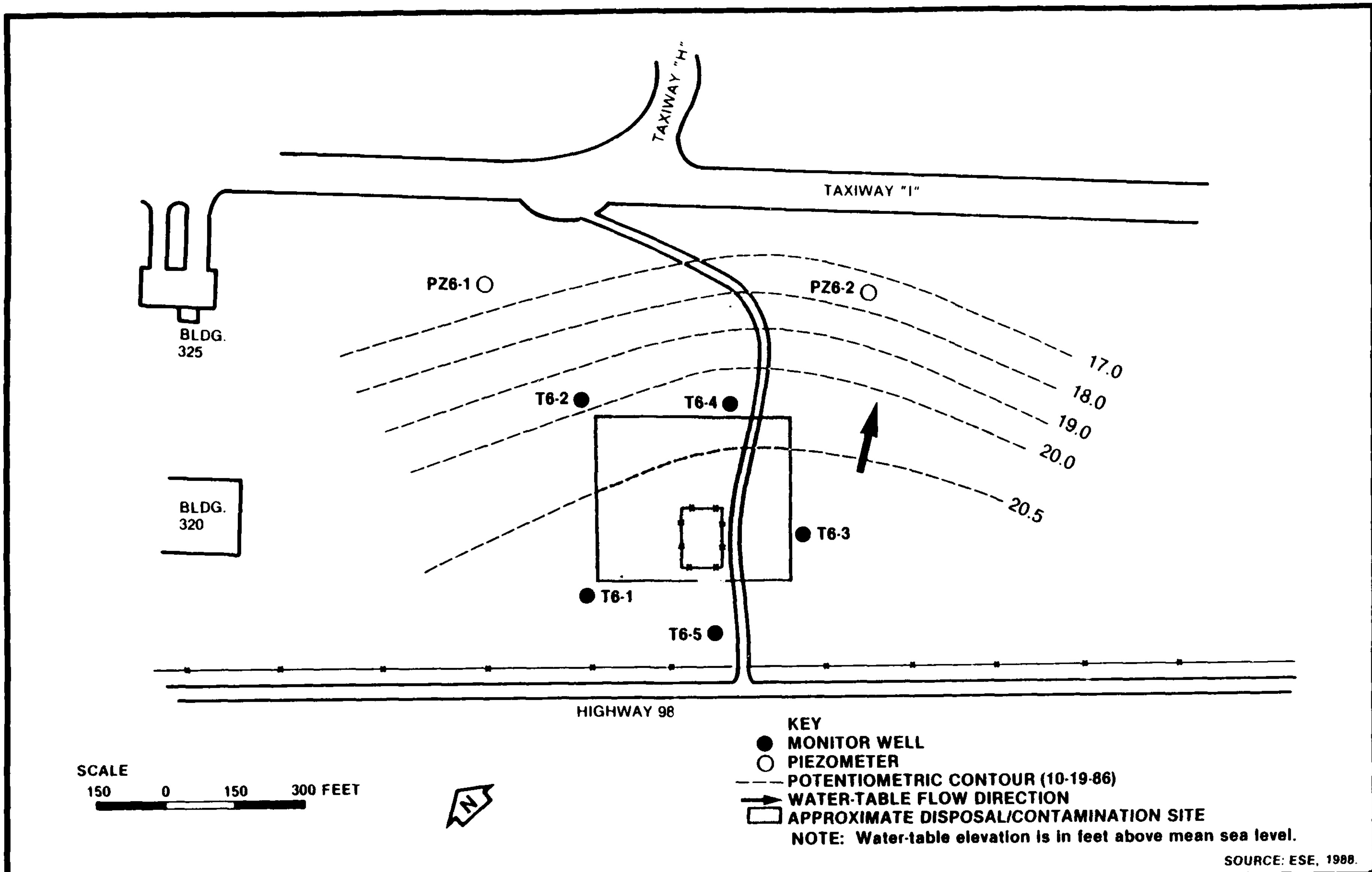

Figure 3.3-4
SITE MAP FOR ZONE 6 — HIGHWAY 98 FIRE TRAINING AREA

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3. Determine if hydrogeologic conditions in the area underlying and adjacent to the site are conducive to contaminant migration; and
4. Determine, if present in the ground water, whether these specific contaminants are migrating downgradient from the area.

Two piezometers were installed at Zone 6. Water-level data from these piezometers were supplemented by water-level data from three pre-existing monitor wells at the site. These data were used to determine the hydraulic gradient of the water table and direction of shallow ground water flow. The locations of the piezometers are depicted in Fig. 3.3-4. Piezometer depths, screened intervals, top of casing elevations, depth to water, and water-table elevations are given in Table 3.3-4. Water-level data indicate ground water flow at Zone 6 is to the northeast.

One upgradient monitoring well (T6-5) and one downgradient monitor well (T6-4) were installed at Zone 6 to supplement three existing monitor wells and to expand the zone of ground water sample extraction.

The locations of all five monitor wells are depicted in Fig. 3.3-4. Monitor well depths, screened intervals, lithology of screened intervals, elevation of the ground surface, and elevation of the water table are given in Table 3.3-4. The five monitor wells were sampled to evaluate the quality of the shallow ground water in the vicinity and to determine whether contaminants were migrating from the site. The samples were analyzed for purgeable organics, acid-extractable organics, petroleum hydrocarbons, and lead.

Due to the sandy nature of the sediments underlying the site, well yield was sufficient to allow continuous pumping during development and purging. Individual well production ranged from 2.2 to 13.6 gpm, with most wells capable of producing greater than 5.0 gpm.

Table 3.3-4. Zone 6 Piezometer and Monitor Well Construction Data and Water Levels

Piezometer Data

Piezometer Designation	Depth (ft)	Screened Interval†	Top of Casing Elevation*	Depth to Water From Top of Casing (ft)	Water-Table Elevation*
PZ6-1	11.5	6.5 to 11.5	21.24	4.34	16.90 (9/30/86)
PZ6-2	11.0	6.0 to 11.0	19.90	2.69	17.21 (9/30/86)

Monitor Well Data

Monitor Well Designation	Depth (ft)	Screened Interval†	Lithology of Screened Interval	Elevation of Ground Surface*	Water-Table Elevation*
T6-1**	19.1	4.3 to 18.3	Sand, trace silt	26.2	20.9 (10/19/86)
T6-2**	20.5	5.7 to 19.7	Sand, 5 to 10% silt	22.1	19.9 (10/19/86)
T6-3**	20.3	5.5 to 19.5	Sand, trace silt	26.3	20.8 (10/19/86)
T6-4	19.0	3.5 to 18.5	Sand, 10% silt	24.0	20.51 (10/19/86)
T6-5	19.5	4.0 to 19.0	Sand	26.2	20.73 (10/19/86

*All elevations in feet above mean sea level.
†Screened interval in feet below ground level.
**Monitor wells installed during Phase II, Stage 1.

Sources: Thiess et al., 1984.
ESE, 1988.

3.3.5 ZONE 7--SOUTHEAST RUNWAY EXTENSION BURIAL SITE

Zone 7, located at the southeast end of the runway near the Alert Facility (Fig. 3.3-5), was used intermittently from 1945 to 1965 for disposal of used containers, drums, old batteries, and old parts.

Objectives of the investigations at Zone 7 were to:

1. Identify specific contaminants which may be present in the shallow surficial aquifer underlying the site; and
2. Determine, if present in the ground water, whether these specific contaminants are migrating downgradient from the area.

The three existing monitor wells at Zone 7 provided adequate control for evaluation of current hydrogeololgic and ground water quality conditions; therefore, no additional monitor wells were installed at the site. Monitor well depths, screened intervals, lithology of screened intervals, elevation of the ground surface, and elevation of the water table are presented in Table 3.3-5. To provide additional information on the quality of ground water in the area and the extent of potential contaminant migration from the site, water samples were obtained from Base Well 11 at the Alert Facility in addition to samples collected from the three monitor wells (T7-1, T7-2, and T7-3). The locations of the three monitor wells and Base Well 11 are depicted in Fig. 3.3-5. All samples were analyzed for purgeable organics, base/neutral and acid-extractable organics, and priority pollutant metals.

3.3.6 ZONE 8--"6000" AREA LANDFILL

Zone 8, located in the "6000" area (Fig. 3.3-6), served as a disposal area for old parts, batteries, and empty containers from 1945 to 1965.

Objectives of investigations at Zone 8 were to:

1. Define the physical extent of the landfill;
2. Define the hydraulic gradient in the shallow aquifer system;

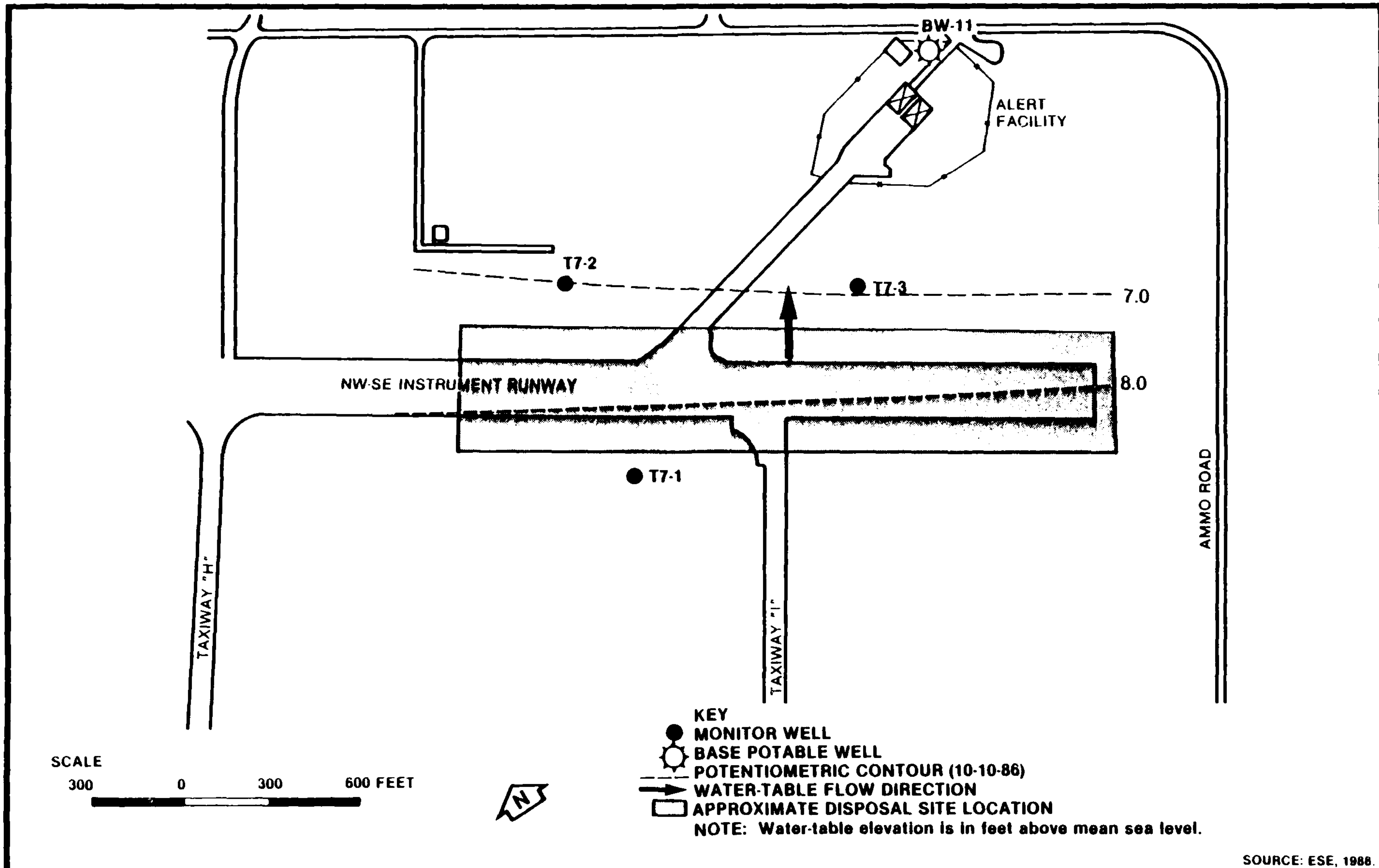

Figure 3.3-5
SITE MAP FOR ZONE 7 — SOUTHEAST RUNWAY EXTENSION LANDFILL

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Table 3.3-5. Zone 7 Monitor Well Construction Data and Water Levels

Monitor Well Designation	Depth (ft)	Screened Interval†	Lithology of Screened Interval	Elevation of Ground Surface*	Water-Table Elevation*
T7-1**	15.3	5.5 to 14.5	Sand, trace silt	10.6	8.8 (10/10/86)
T7-2**	15.3	5.5 to 14.5	Sand, trace silt	9.6	7.0 (10/10/86)
T7-3**	15.3	5.8 to 14.8	Sand, trace silt	8.5	7.1 (10/10/86)
T7-4††	115	110 to 115	—	—	—

*All elevations in feet above mean sea level.
†Screened interval in feet below ground level.
**All Zone 7 monitor wells installed during Phase II, Stage 1.
††Not a monitor well (Base Well 11).

Sources: Thiess et al., 1984.
ESE, 1988.

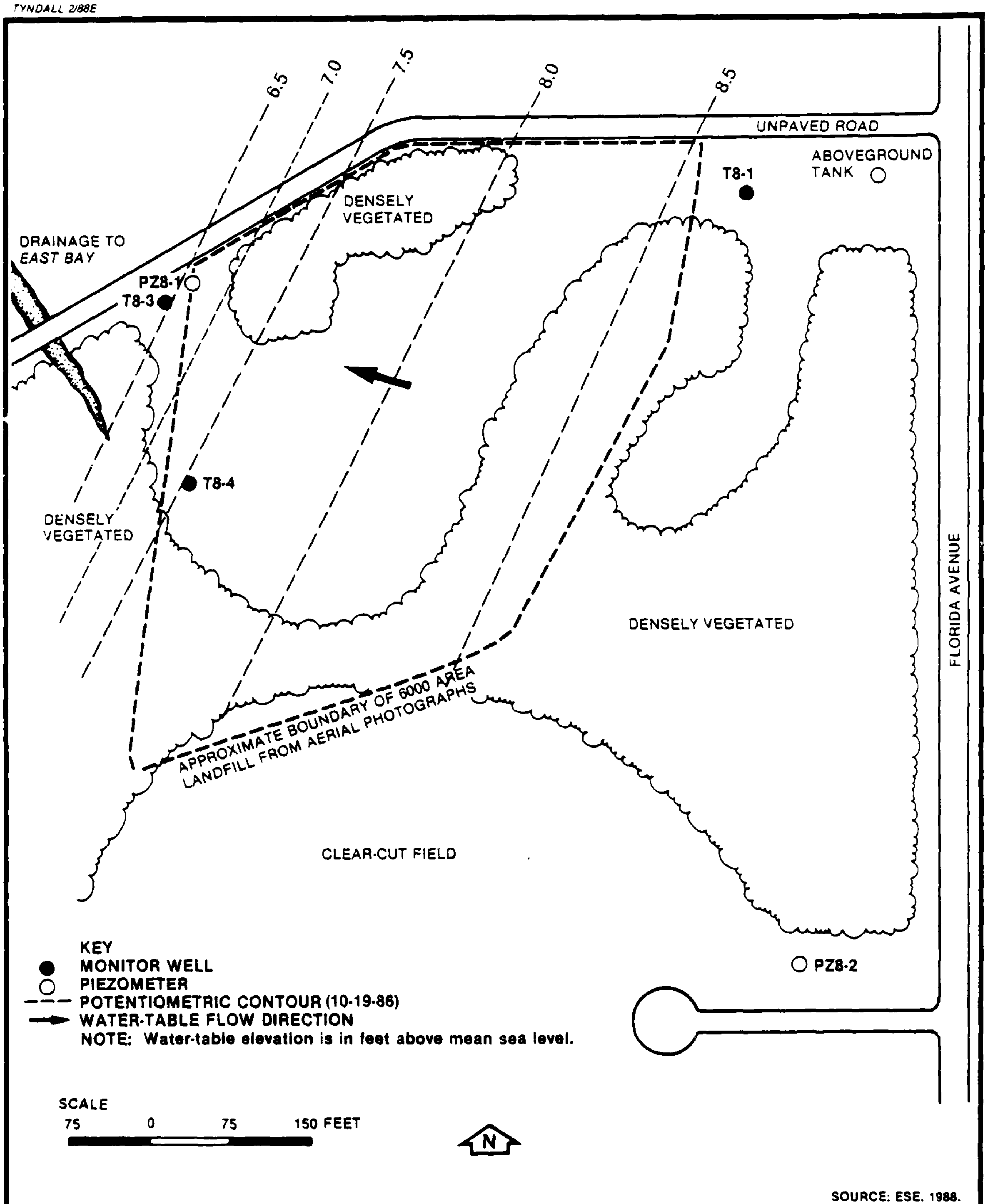

Figure 3.3-6
SITE MAP FOR ZONE 8 — "6000" AREA LANDFILL

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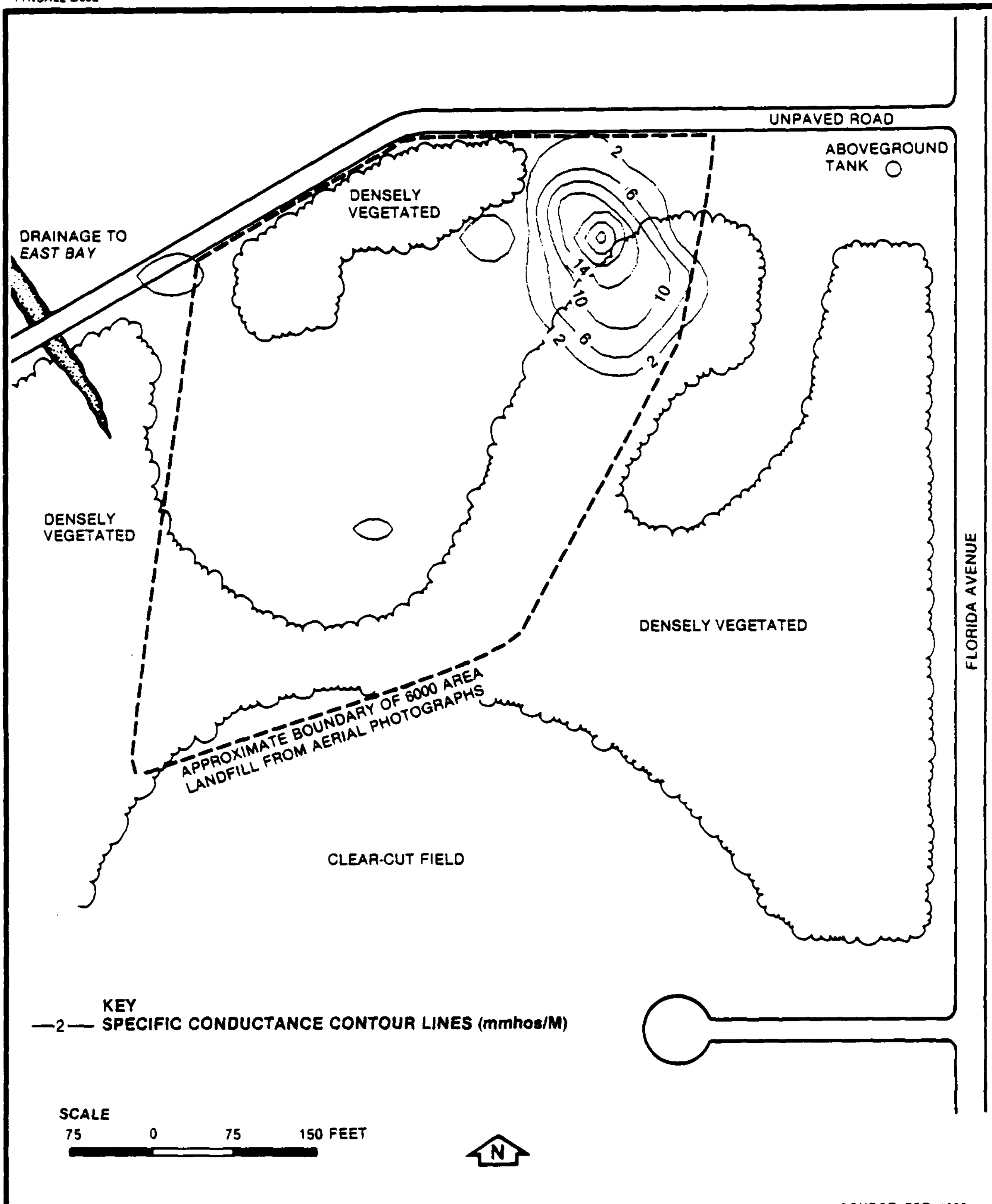
3. Identify specific contaminants which may be present in the shallow surficial aquifer underlying the site;
4. Determine if hydrogeologic conditions in the area underlying and adjacent to the site are conducive to contaminant migration; and
5. Determine, if present in the ground water, whether these specific contaminants were migrating from the area.

A detailed geophysical survey incorporating magnetometer and EM techniques was conducted at the "6000" Area Landfill to delineate the lateral extent of the site and to determine whether any leachate plumes could be identified at the disposal area. Fig. 3.3-7 is a contour map of subsurface conductivities at the site using unaltered measurements obtained from the EM survey. Fig. 3.3-8 is a modified version of this database, adjusting or eliminating measurements where visible surface contamination by ferromagnetic or other high-conductivity (i.e., asphaltic) material was observed. The geophysical tracings for Zone 8 are provided in Appendix G.

Results of the geophysical survey indicated the presence of metallic objects buried in the disposal area (Appendix G). Fig. 3.3-7, using all data including measurement sites with visible high-conductivity materials or anomalous magnetometer responses, indicates an area located in the north-central portion of the landfill with exceptionally high conductivities relative to other adjacent areas. This is probably due to the occurrence of considerable amounts of buried metallic debris in the subsurface. The survey did not conclusively indicate the presence of a leachate plume; however, elevated conductivity measurements along the northern and western portion of the landfill were obtained in areas where no anomalous readings were recorded by the magnetometer (Fig. 3.3-8). These areas are downgradient from the landfill and could indicate the presence of a contaminant plume. However, this downgradient area was adjacent to a hardwood swamp, which is underlain by fine-grained silts and clays. Conductivity measurements obtained by the EM survey are a



SOURCE: ESE. 1988.

Figure 3.3-7
ZONE 8 — AREA "6000" LANDFILL
UNCORRECTED RESULTS OF SURFACE GEOPHYSICAL SURVEY

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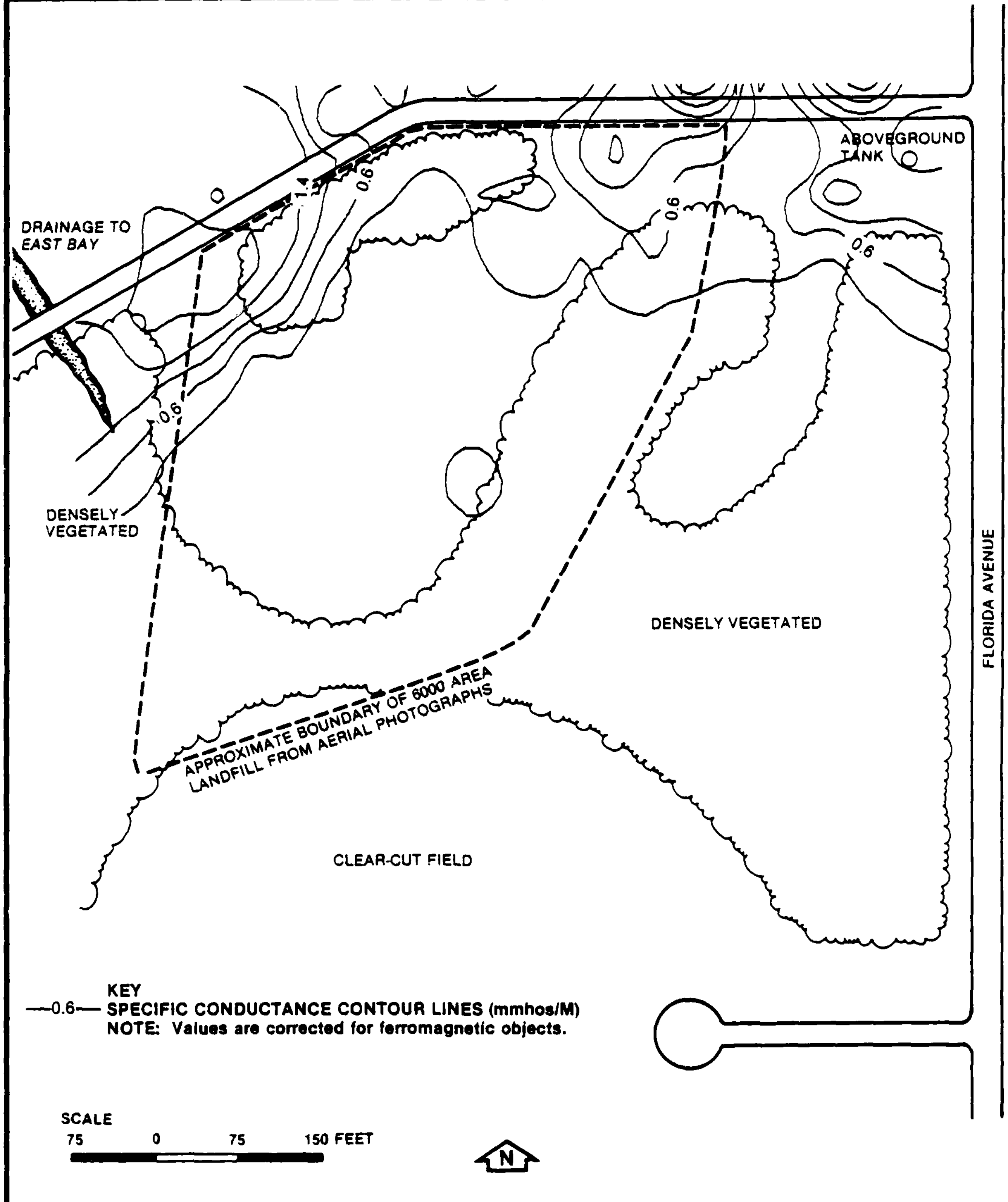

SOURCE: ESE, 1988.

Figure 3.3-8
ZONE 8 — AREA "6000" LANDFILL
CORRECTED RESULTS OF SURFACE
GEOPHYSICAL SURVEY

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function of the conductivity of both the pore fluid and the sediment type underlying the site. Hardwood swamp environments can promote the precipitation of iron compounds in clayey sediments, therefore causing elevated conductivity readings relative to clean sands. Since much of the landfill is underlain by sand where low subsurface conductivities were recorded, the somewhat elevated downgradient responses obtained by the EM conductivity meter were possibly a function of the presence of clays. The results of the geophysical surveys do not conclusively indicate the presence of a contaminant plume in the pore fluids.

Exceptionally low conductivity values were obtained across much of the upgradient portion of the landfill. Discussions with representatives of Geonics Limited, the manufacturer of the EM meter used to conduct the survey at Tyndall AFB, indicate these low measurements are not highly unusual and were probably a function of clean sands with little or no silt or clay content. Often when soils have been disturbed (such as landfilling) and are not in their natural setting, they are not as densely packed, which would contribute to lower conductivity values. These low conductivity measurements are a strong indication that no contaminant plume exists in the upgradient portion of the landfill.

Two piezometers were installed at Zone 8. Water-level data from these piezometers supplemented by water-level data from pre-existing monitor well T8-1 were used to determine the configuration of the water table and predict the direction of shallow ground water flow at the site. Monitor well T8-2, which was installed during the Phase II Stage I investigations, was damaged by vehicular traffic and is no longer useable. The location of the two piezometers is depicted in Fig. 3.3-6. Piezometer depths, screened intervals, top of casing elevations, depth to water, and water-table elevations are given in Table 3.3-6. Water-level data indicate ground water flow is to the west-northwest at Zone 8.

Aerial photographs of the "6000" Area provided by the Tyndall AFB Civil Engineering Squadron and taken about the time "6000" Area landfilling activities ceased indicated the landfill was much more extensive than indicated in the Phase II, Stage 1 study. Based on analysis of these

Table 3.3-6. Zone 8 Piezometer and Monitor Well Construction Data and Water Levels

Piezometer Data

Piezometer Designation	Depth (ft)	Screened Interval†	Top of Casing Elevation*	Depth to Water From Top of Casing (ft)	Water-Table Elevation*
PZ8-1	12.5	2.0 to 12.0	10.79	4.20	6.59 (9/30/86)
PZ8-2	9.5	4.5 to 9.5	15.75	7.08	8.67 (9/30/86)

Monitor Well Data

Monitor Well Designation	Depth (ft)	Screened Interval†	Lithology of Screened Interval	Elevation of Ground Surface*	Water-Table Elevation*
T8-1**	15.3	5.5 to 14.5	Sand, trace to 25% silt	13.0	8.7 (10/19/86)
T8-3	17.5	2.0 to 17.0	Sand, 10% silt	8.4	6.41 (10/19/86)
T8-4	19.0	3.5 to 18.5	Sand, 0 to 25% silt	10.4	7.53 (10/19/86)

*All elevations in feet above mean sea level.
†Screened interval in feet below ground level.
**Monitor well installed during Phase II, Stage 1.

Sources: Thiess et al., 1984.
ESE, 1988.

photographs and incorporating the results of the geophysical survey and piezometer water-level measurements, it was determined that existing Well T8-1 was upgradient of the landfill area. Based on the additional information on the areal extent of the "6000" Area Landfill and the direction of ground water flow, following consultation with the USAF Project Manager, it was decided to install two new downgradient monitor wells in deviation from the approved Technical Operations Plan. This modification of the original work plan was verified by the USAF and was carried out to more appropriately assess the extent of contamination at Zone 8.

The locations of the two new monitor wells and pre-existing monitor well T8-1 are depicted in Fig. 3.3-6. Monitor well depths, screened intervals, lithology of screened intervals, elevation of the ground surface, and elevation of the water table are given in Table 3.3-6. Monitor well T8-2, installed during the Phase II Stage 1 investigation, was damaged by vehicular traffic and is no longer useable. The modified monitor well network at Zone 8 provided the framework from which to sample the ground water across a much more extensive area, in light of the new findings concerning past landfill operations. The three monitor wells were sampled to evaluate the quality of the shallow ground water in the vicinity and to determine if contaminants were migrating from the site. Ground water samples were analyzed for purgeable organics, base/neutral and acid-extractable organics, and priority pollutant metals.

3.3.7 ZONE 9--POL AREA B

Zone 9, located just south of Florida Avenue in the industrial section of Tyndall AFB (Fig. 3.3-9), is a relatively small POL storage area which may have sludge buried onsite. Specific types of fuel stored at this site include: JP4, Diesel Fuel Number 2, and motor gasoline.

Objectives of the investigations at Zone 9 were to:

1. Determine the hydraulic gradient in the shallow aquifer system;
2. Identify specific contaminants which may be present in the shallow surficial aquifer underlying the site;

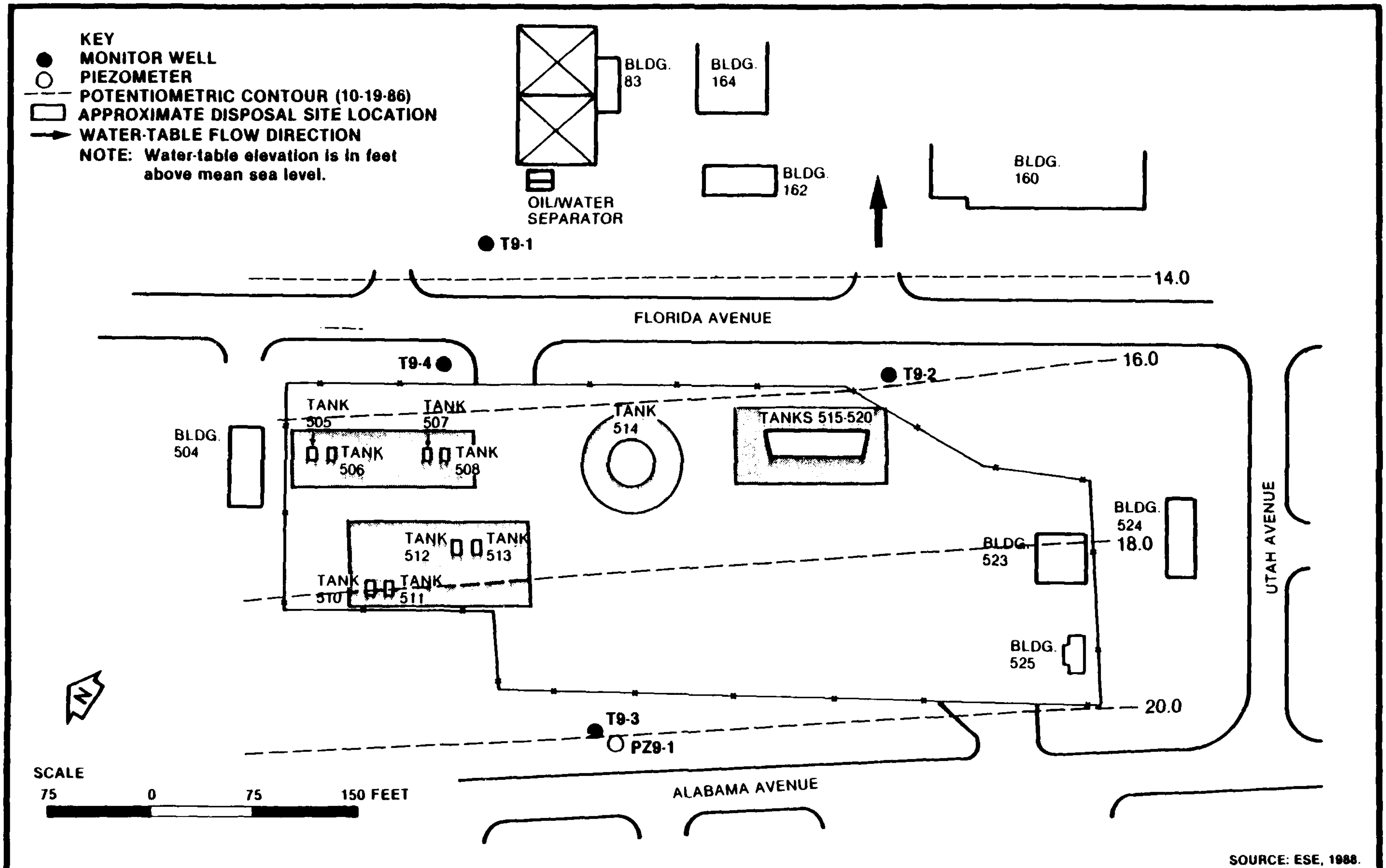

Figure 3.3-9
SITE MAP FOR ZONE 9 — POL AREA B

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3. Determine if hydrogeologic conditions in the area underlying and adjacent to the site are conducive to contaminant migration; and
4. Determine, if present in the ground water, whether these specific contaminants are migrating from the area.

One piezometer was installed at Zone 9, and water-level data from this piezometer, in conjunction with water-level data from two pre-existing monitor wells, were used to determine the direction of shallow ground water flow at the site. The location of the piezometer is depicted in Fig. 3.3-9. The piezometer depth, screened interval, top of casing elevations, depth-to-water, and water-table elevations are given in Table 3.3-7. Water-level data indicate ground water flow at Zone 9 is toward the northeast, and monitor well locations were selected accordingly.

One upgradient monitor well (T9-3) and one downgradient monitor well (T9-4) were installed at Zone 9 to supplement the existing monitor well network. Onsite measurement of organic vapors indicated the presence of contaminants in the cuttings, so all cuttings were containerized in drums for removal from the site. Cuttings from this site were analyzed for EP toxicity and found to be below the criteria to be classified as a hazardous waste. The pre-existing well, T9-1, while adequately positioned to intercept downgradient flow from Zone 9, was not situated close enough to the site to eliminate other possible sources of water quality interference. An oil/water separator unit lies less than 100 ft away from T9-1 and could be a more pertinent contributor to ground water quality in the vicinity of T9-1 than the POL tanks, which lie about 200 ft away, across Florida Avenue.

Surface runoff from Florida Avenue may also affect the shallow water-table gradient between Well T9-1 and Tanks 505 through 513, due to the close proximity of the water table to the land surface. Therefore,

Table 3.3-7. Zone 9 Piezometer and Monitor Well Construction Data and Water Levels

Piezometer Data

Piezometer Designation	Depth (ft)	Screened Interval†	Top of Casing Elevation*	Depth to Water From Top of Casing (ft)	Water-Table Elevation*
PZ9-3	16.5	6.5 to 16.5	27.64	6.72	20.92 (9/30/86)

Monitor Well Data

Monitor Well Designation	Depth (ft)	Screened Interval†	Lithology of Screened Interval	Elevation of Ground Surface*	Water-Table Elevation*
T9-1**	20.2	5.4 to 19.4	Sand, trace to 10% silt	17.9	13.6 (10/19/86)
T9-2**	20.6	5.8 to 19.8	Sand, trace to 20% silt	20.2	15.9 (10/19/86)
T9-3	19.5	4.0 to 19.0	Sand	26.1	20.00 (10/19/86)
T9-4	18.5	3.0 to 18.0	Sand, 10% silt	21.8	15.10 (10/19/86)

*All elevations in feet above mean sea level.
†Screened interval in feet below ground level.
**Monitor wells installed during Phase II, Stage 1.

Sources: Thiess et al., 1984.
ESE, 1988.

an additional monitor well (T9-4) was installed on the south side of Florida Avenue on the outside of the fence directly west of the facility entrance. An upgradient monitor well (T9-3) was installed about 200 ft southwest of Tank 514 to establish background ground water quality for Zone 9. Existing Well T9-2 is adequately positioned to evaluate ground water quality downgradient from POL Storage Tanks 515 through 520. The locations of all four monitor wells are depicted in Fig. 3.3-9. The monitor well depths, screened intervals, lithology of the screened intervals, elevation of the ground surface, and elevation of the water table are given in Table 3.3-7. The four monitor wells were sampled to evaluate the quality of the shallow ground water in the vicinity and to determine whether contaminants were migrating from the site. The samples were analyzed for purgeable organics, EDB, petroleum hydrocarbons, and lead.

3.3.8 ZONE 10--"SHELL BANK" FIRE TRAINING AREA

Zone 10, located at the northwest end of the runway adjacent to Shoal Point Bayou (Fig. 3.3-10), was used for fire-training exercises between 1943 to 1952 and from 1968 to 1980.

Objectives of the investigations at Zone 10 were to:

1. Define the hydraulic gradient in the shallow aquifer system;
2. Identify specific contaminants which may be present in the shallow surficial aquifer underlying the site;
3. Determine if hydrogeologic conditions in the area underlying and adjacent to the site are conducive to contaminant migration; and
4. Determine, if present in the ground water, whether these specific contaminants were migrating downgradient from the area.

Since no monitor wells existed at Zone 10 prior to this investigation, three piezometers were installed and water-level measurements were obtained to determine the configuration of the water table and predict the direction of shallow ground water flow at the site. The location of

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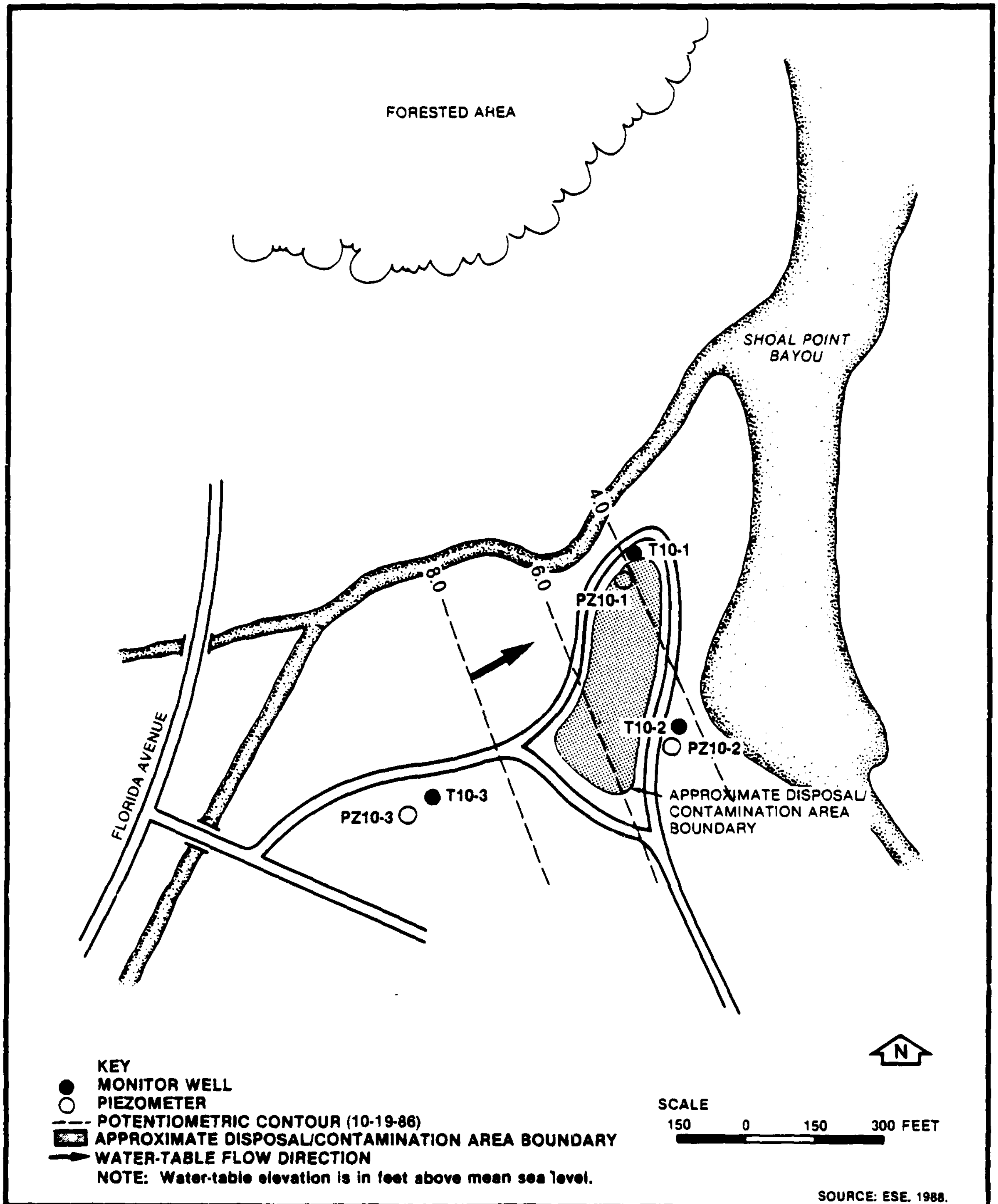

Figure 3.3-10 SITE MAP FOR ZONE 10— "SHELL BANK" FIRE TRAINING AREA	**INSTALLATION RESTORATION PROGRAM** **Tyndall Air Force Base**

the piezometers is depicted in Fig. 3.3-10. The piezometer depths, screened intervals, top of casing elevations, depth-to-water, and water-table elevation are described in Table 3.3-8. Water-level data suggest ground water flow at Zone 10 is to the east-northeast, toward Shoal Point Bayou, and monitor well locations were selected accordingly.

One upgradient monitor well (T10-3) and two downgradient monitor wells (T10-1 and T10-2) were installed at Zone 10. The locations of the three monitor wells are depicted in Fig. 3.3-10. The monitor well depths, screened intervals, lithology of the screened intervals, elevation of the ground surface and elevation of the water table are given in Table 3.3-8. The three monitor wells were sampled to evaluate the quality of the shallow ground water in the vicinity and to determine whether contaminants were migrating from the site. The samples were analyzed for purgeable organics, acid-extractable organics, petroleum hydrocarbons, and lead.

3.3.9 ZONE 11--ACTIVE FIRE TRAINING AREA

Zone 11, located northeast of the Tyndall AFB runway adjacent to Little Cedar Bayou (Fig. 3.3-11), has been used as a fire-training area since 1981.

Objectives of the investigations at Zone 11 were to:

1. Determine the extent of soil contamination from spills and wind deposition in areas of visual surface contamination;
2. Determine whether waters discharged from an oil/water separator, surface drainage, or ground water discharge were transporting contaminants into Little Cedar Bayou;
3. Identify specific contaminants, if present, which are being released into the surface waters and sediments of Little Cedar Bayou;
4. Define the hydraulic gradient in the shallow aquifer system;

Table 3.3-8. Zone 10 Piezometer and Monitor Well Construction Data and Water Levels

Piezometer Data

Piezometer Designation	Depth (ft)	Screened Interval†	Top of Casing Elevation*	Depth to Water From Top of Casing (ft)	Water-Table Elevation*
PZ10-1	8.5	0.5 to 8.5	12.32	**	**
PZ10-2	16.0	6.0 to 16.0	13.43	8.20	5.23 (9/30/86)
PZ10-3	10.5	1.5 to 10.5	12.71	4.12	8.59 (9/30/86)

Monitor Well Data

Monitor Well Designation	Depth (ft)	Screened Interval†	Lithology of Screened Interval	Elevation of Ground Surface*	Water-Table Elevation*
T10-1	20.0	4.5 to 19.5	Sand, 10 to 50% silt	10.9	3.96 (10/19/86)
T10-2	19.8	4.3 to 19.3	Sand, 10 to 15% silt	12.2	4.38 (10/19/86)
T10-3	20.0	4.5 to 19.5	Sand, approx. 30% silt	11.2	8.58 (10/19/86)

*All elevations in feet above mean sea level.
†Screened interval in feet below ground level.
**Piezometer dry to bottom of casing.

Source: ESE, 1988.

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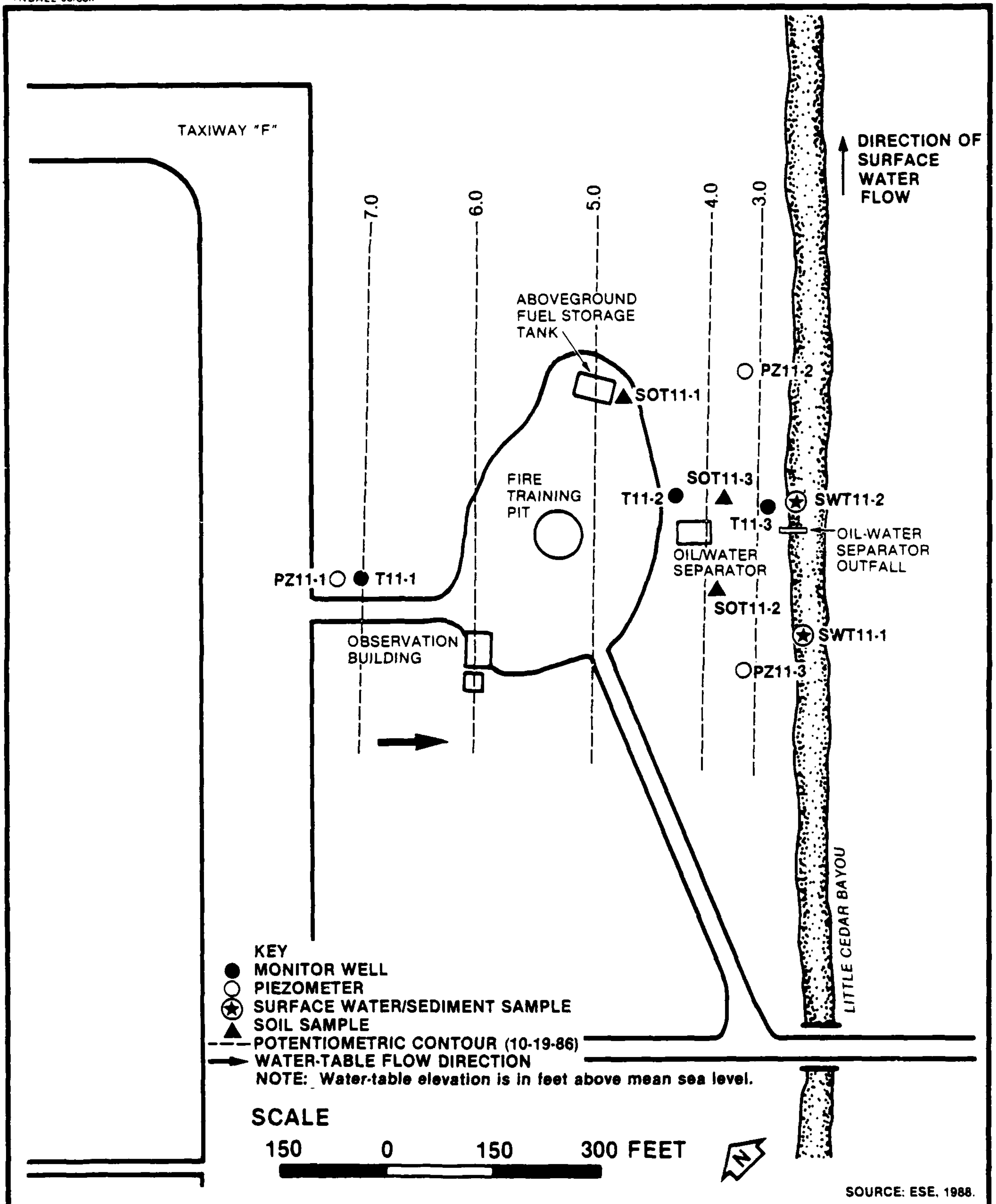

Figure 3.3-11
SITE MAP FOR ZONE 11 — ACTIVE FIRE TRAINING AREA

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5. Identify specific contaminants which may be present in ground water underlying the site;
6. Determine if hydrogeologic conditions in the area underlying and adjacent to the site are conducive to contaminant migration; and
7. Determine, if present in the ground water, whether these specific contaminants were migrating downgradient from the area.

Soil borings were collected at three locations within Zone 11 where spills had visibly impacted the surface vegetation and soil. The location of the soil borings are depicted in Fig. 3.3-11. Continuous split-spoon sampling was conducted from the ground surface to a depth of 10 ft, with samples visibly contaminated collected for laboratory analysis. Three samples were collected to determine the extent of soil contamination. Soil boring descriptions and sampled intervals are provided in Appendix N.

Sediment and surface water samples were collected from Little Cedar Bayou at two locations, which are depicted in Fig. 3.3-11. One location was immediately adjacent to the outfall of the oil/water separator discharge pipe, whereas the other location was approximately 150 ft from the discharge outfall. These samples were collected to evaluate the quality of the water being discharged from the oil/water separator and to determine if contaminants are being introduced into Little Cedar Bayou or accumulating in the creek sediments. The purpose of collecting samples at the two locations was to determine if surface drainage or ground water discharge played a role in the introduction of contamination to the bayou.

Since no monitor wells existed at Zone 11 prior to this investigation, three piezometers were installed and water-level measurements obtained to determine the direction of shallow ground water flow at the site. The locations of the piezometers are depicted in Fig. 3.3-11. Piezometer

depths, screened intervals, top of casing elevations, depth to water, and water-table elevation are given in Table 3.3-9. Water-level data indicated ground water flow at Zone 11 was to the southeast, and monitor well locations were selected accordingly.

One upgradient monitor well (T11-1) and two downgradient monitor wells (T11-2 and T11-3) were installed at Zone 11 to develop an adequate monitor well network for ground water sampling. The locations of the three monitor wells are depicted in Fig. 3.3-11. The monitor well depths, screened intervals, lithology of the screened intervals, elevation of the ground surface and elevation of the water table are presented in Table 3.3-9. The three monitor wells were sampled to evaluate the quality of the shallow ground water in the vicinity and to determine whether contaminants were migrating from the site. The samples were analyzed for purgeable organics, acid-extractable organics, petroleum hydrocarbons, and lead.

Table 3.3-9. Zone 11 Piezometer and Monitor Well Construction Data and Water Levels

Piezometer Data

Piezometer Designation	Depth (ft)	Screened Interval†	Top of Casing Elevation*	Depth to Water From Top of Casing (ft)	Water-Table Elevation*
PZ11-1	10.0	0.0 to 10.0	12.18	4.37	7.81 (9/30/86)
PZ11-2	12.0	7.0 to 12.0	8.29	4.65	3.64 (9/30/86)
PZ11-3	12.0	7.0 to 12.0	8.82	5.00	3.82 (9/30/86)

Monitor Well Data

Monitor Well Designation	Depth (ft)	Screened Interval†	Lithology of Screened Interval	Elevation of Ground Surface*	Water-Table Elevation*
T11-1	20.0	4.5 to 19.5	Sand, 10% silt	11.0	6.95 (10/19/86)
T11-2	19.5	4.0 to 19.0	Silty sand	10.7	4.35 (10/19/86)
T11-3	19.0	3.5 to 18.5	Sand, 10% silt	6.3	2.58 (10/19/86)

*All elevations in feet above mean sea level.
†Screened interval in feet below ground level.

Source: ESE, 1988.

4.0 RESULTS

4.1 CONTAMINATION EVALUATION CRITERIA

This section describes applicable state and Federal water quality criteria for contaminants detected in surface and ground water at Tyndall AFB during the Phase II, Stage 2 study. The standards and criteria described herein are the basis on which assessment of significant contamination of surface and ground water is determined.

4.1.1 DRINKING WATER CRITERIA

Pursuant to Sec. 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (Public Law 93-523), EPA has promulgated National Primary Drinking Water Regulations (NPDWR) (EPA, 1986a) and National Secondary Drinking Water Regulations (NSDWR) (EPA, 1986b). These regulations establish primary and secondary Maximum Contaminant Levels (MCLs) for certain inorganic and organic substances in drinking water. NPDWR addresses contaminants which adversely affect health, whereas NSDWR addresses contaminants that affect aesthetic qualities relating to the acceptance of drinking water.

In November 1985, EPA proposed the National Revised Primary Drinking Water Regulations (EPA, 1985a) which included both recommended maximum contaminant levels (RMCLs) and MCLs. RMCLs are currently nonenforceable health goals which are levels set so that no known or anticipated adverse health effects occur with an adequate margin of safety. MCLs are enforceable standards and are set as close to the RMCL as is feasible, based on technology and cost considerations.

Standards established by these regulations are not directly applicable to ground waters sampled during the Tyndall AFB Phase II, Stage 2 survey because the regulations pertain to water within public drinking water systems. However, MCLs and RMCLs can be used as criteria in the

assessment of significant ground water contamination. The relevant MCLs and RMCLs established by EPA are presented in Table 4.1-1. MCLs and RMCLs have not been established for all survey parameters examined during this study.

The State of Florida has established a system of ground water and surface water classifications according to designated use. All ground water in the Tyndall AFB area is designated as Class G-II [for potable water use, with a total dissolved solids (TDS) content of less than 10,000 mg/L].

Sec. 17-3.404 of the Florida Administrative Code (FAC) (FDER, 1983) states that all Class G-II ground waters must meet State of Florida primary and secondary drinking water quality standards established by the Florida Safe Drinking Water Act (FDER, 1982), unless natural background concentrations exceed the standards. In such cases, the representative background value shall be the prevailing standard. State of Florida criteria for Class G-II ground waters will be used to assess contamination of ground water samples collected at Tyndall AFB. The relevant MCLs established for the State of Florida primary and secondary drinking water standards are presented in Table 4.1-1. MCLs have not been established for all survey parameters.

For some organic chemicals detected during the Phase II, Stage 2 survey, no Federal or state MCLs exist. For those parameters, the drinking water criteria used for comparison will be the Health Advisory Levels listed in Table 4.1-1 that have been prepared by the EPA Office of Drinking Water Health Advisory Program (EPA, 1987). Health advisories are nonregulatory guidance that provide information on health effects, analytical methodology, and treatment technology that would be useful in dealing with contamination of drinking water. The advisories are considered to be exposure levels which would be protective for noncarcinogenic endpoints of toxicity over a lifetime of exposure for a 70-kilogram (kg)

Table 4.1-1. Relevant EPA Water Quality Criteria* for the Protection of Human Health for Contaminants Detected (Continued, Page 2 of 2)

	Drinking Water Standards* (ug/L)		Lifetime Health++ Advisory (ug/L)	Ambient Water Quality Criteria*** (ug/L)			
				Ingestion of Water and Aquatic Organisms		Ingestion of Aquatic Organisms Only	
	RMCL	MCL		Toxicity	Carcinogenicity (10^{-6})	Toxicity	Carcinogenicity (10^{-6})
trans-1,2-Dichloroethene	70**		70				
1,2-Dichloropropane	6**						
Ethylbenzene	680**		680	1,400		3,280	
Methylene Chloride					0.19		15.7
Bis(2-Ethylhexyl)phthalate			700+++	15,000		50,000	
Toluene	2,000**		2,000	14,300		424,000	
1,1,1-Trichloroethane	200	200(200)	200	18,400		1,030,000	
Trichloroethene	0	5(3)	260		2.7		80.7
Vinyl Chloride	0	1(1)			2.0		525
Xylene			440				

*NPDWR (EPA, 1986); NSDWR (EPA, 1986); Levels in Parentheses are State of Florida Drinking Water Criteria (FAC 17-22).
+Total Trihalomethanes Criterion (total concentration of Bromoform, Chlorodibromomethane, Chloroform, and Dichlorobromomethane must meet the 100-ug/L criterion).
**Proposed Value.
++Lifetime Health Advisories (EPA, 1987).
***Ambient Water Quality Criteria (EPA, 1980; 1981).
+++The human health based value for bis(2-ethylhexyl)phthalate is 700 ppb based on the reference dose of 0.02 mg/kg/day assuming consumption of 2 liters of water per day by a 70-kg adult. This value has not been calculated by EPA (1987) but is presented here for comparison purposes.

Source: ESE, 1988.

Table 4.1-1. Relevant EPA Water Quality Criteria* for the Protection of Human Health for Contaminants Detected

	Drinking Water Standards* (ug/L)		Lifetime Health++ Advisory (ug/L)	Ambient Water Quality Criteria*** (ug/L)			
				Ingestion of Water and Aquatic Organisms		Ingestion of Aquatic Organisms Only	
	RMCL	MCL		Toxicity	Carcinogenicity (10^{-6})	Toxicity	Carcinogenicity (10^{-6})
pH (Standard Water)		6.5-8.5					
Arsenic	50**	50(50)	50		0.0022		0.0175
Beryllium					0.0068		0.117
Chromium	120**	50(50)	120	50			
Copper	1,300**	1,000(1,000)					
Lead	20**	50(50)	20	50			
Mercury	3**	2(2)	1.1	0.144		0.146	
Nickel			150	13.4		100	
Selenium	45**	10(10)		10			
Silver		50(50)		50			
Thallium				13		48	
Zinc							
Benzene	0	5(1)			0.66		40
Bromodichloromethane		100+(100)			0.19+		15.7+
Chlorobenzene	60**		300	488		15,050	
Chloroform		100+(100)			0.19+		15.7+
Chloromethane					0.19		15.7
Dichlorobenzene	75	75	75	400		2,600	
1,2-Dichloroethane	0	5(3)			0.94		243
1,1-Dichloroethene	7	7	7		0.033		1.85

adult ingesting 2 liters (L) of water per day. The levels presented in Table 4.1-1 are adjusted for estimated actual exposure from drinking water alone.

4.1.2 AQUATIC LIFE CRITERIA

Pursuant to Sec. 304 of the Clean Water Act, EPA (1976) developed water quality criteria for the protection of human health and aquatic life. In 1980, EPA criteria were updated for the 64 toxic pollutants or pollutant categories named in Sec. 307A of the Clean Water Act, based on evaluation of new toxicological and environmental data and changes in methodology of the hazard/risk assessment (EPA, 1980). The 1980 criteria for some parameters were subsequently revised in 1981 and 1985 (EPA, 1981; 1985b). Current EPA criteria consider both the acute and chronic adverse effects of pollutants on aquatic organisms, nonhuman mammals, and humans and have been designed to protect aquatic life and humans for effect of exposure to the pollutants.

The level of protection afforded aquatic organisms by the 1980, 1981, and 1985b EPA criteria is established so that most aquatic life would be protected and aquatic ecosystem functions would be preserved. However, a few untested sensitive species might be adversely affected if the highest allowable concentrations persisted for long periods of time. The 1980, 1981, and 1985b EPA criteria specify concentrations both in terms of 24-hour averages and maximum concentrations not to be exceeded at any time. Because the sampling program at Tyndall AFB did not quantify 24-hour averages, assessments of potential effects of aquatic life have been made by comparison to EPA criteria, which are the maximum allowable concentrations at any time.

Ground water samples collected at Tyndall AFB were taken from unconsolidated sandy deposits underlying the study site. Ground water in this formation could discharge to downgradient surface drainages as well as adjacent surface waters including North Bay, East Bay, and the Gulf of Mexico.

Both North Bay and East Bay have been classified by the State of Florida as Class II surface waters for the beneficial use of shellfish propagation and harvesting, as specified in Sec. 17.3.111 FAC (FDER, 1986). The remainder of surface waters, including the Gulf of Mexico, are classified as Class III surface waters by the State of Florida for the beneficial uses of recreation and propagation and maintenance of a healthy, well-balanced population of fish and wildlife (Sec. 17-3.3121 FAC) (FDER, 1986). FDER has established separate water quality criteria for Class II and Class III surface waters (Sec. 17-3.111 FAC and Section 17.3.121 FAC, respectively) (FDER, 1986). State of Florida water quality criteria for Class II and III surface waters, which are relevant to the current study, are presented in Table 4.1-2. Both Class II and Class III surface waters criteria are applicable to samples collected at Tyndall AFB and will be used to assess water quality data obtained during this study. The use of either class will be dependent on the designation of the receiving surface water body at each zone.

The EPA (1980, 1981, and 1985b) ambient water quality criteria for the protection of aquatic life will be used to evaluate the surface water samples collected during the Phase II, Stage 2 investigations at Tyndall AFB.

4.1.3 HUMAN HEALTH CRITERIA

Human health criteria incorporated in the EPA 1980 criteria are based on carcinogenic, toxic, or organoleptic (taste and/or odor) properties of the 64 compounds. These human health criteria have been developed based on the assumption that a 70-kg adult will consume 2 L of drinking water and 6.5 gram (g) of fish or other aquatic life per day containing the stated maximum concentrations for a particular contaminant. For noncarcinogens, the criteria have been based on the prevention of adverse health effects in humans due to toxicity. In the case of known or suspected carcinogens, the criteria represent incremental increases in the cancer risk to exposed populations. In assessing the human health

Table 4.1-2. Relevant Surface Water Quality Criteria for Contaminants Detected at Tyndall AFB

Parameter	State of Florida Water Quality Criteria* (µg/L)		EPA Water Quality Criteria† For Saltwater Aquatic Life (µg/L)	
	Class II Surface Water	Class III Surface Water	Acute Toxicity	Chronic Toxicity
pH (Standard Units)	6.5–8.5	6.5–8.5		
Arsenic	50	5	69	36
Beryllium		1,100		
Chromium	50	50	1,100	50
Copper	15	15	2.9	2.9
Lead	50	50	140††	5.6††
Mercury	0.1	0.1	2.1	0.025
Nickel	100	100	140	7.1
Selenium	25	25	410	54
Silver	0.05	0.05	2.3	
Zinc	1,000	1,000	170	58
Benzene			5,100**	700**
Chlorobenzene			160**	129**
Chloromethane			270,000**	
Dichlorobenzene			1,970**	
1,2-Dichloroethane			113,000**	
1,1-Dichloroethene			224,000**	
1,2-Dichloropropane			10,300**	3,040**
Ethylbenzene			430**	
Methylene Chloride			256,000**	
Toluene			6,300**	5,000**
1,1,1-Trichloroethane			31,200**	
Trichloroethene			2,000**	

*State of Florida Surface Water Quality Criteria for Class II and Class III waters (FAC 17-3).
†EPA Ambient Water Criteria for Saltwater Aquatic Life (EPA, 1980; 1981; 1985).
**Insufficient Data to Develop Criteria; Value Presented is the Lowest-Observed-Effect Level (LOEL).
††Hardness—Dependent Criteria (100 mg/L used).

Source: ESE, 1988.

significance of contaminants found at Tyndall AFB, the incremental risk level chosen was 10^{-6}. This level corresponds to an increased cancer risk of no more than 1 in 1,000,000 exposed individuals. The applicable human health criteria for the contaminants detected at Tyndall AFB are shown in Table 4.1-1. Surface waters adjacent to Tyndall AFB are tidally influenced (saline) and are not used for potable supply. For this reason, only the ambient water quality criteria for human health for consumption of organisms (fish) taken from the water are used to evaluate surface water quality data in this assessment. Ambient water quality human health criteria for consumption of water and aquatic organisms will be used to evaluate ground water at Tyndall AFB, only for those specific contaminants detected in ground water samples for which no MCL or health advisory criteria exist. The methodology for development of the criteria for protection of both human health and aquatic life are summarized in EPA (1980). No sediment or soil criteria have been developed.

4.2 ANALYTICAL RESULTS

Sample collections and *in situ* measurements were performed between October 9 and October 23, 1986. Samples were collected and sent to ESE's laboratory in Gainesville, Florida, with 10 percent duplicate samples sent to OEHL's laboratory at Brooks AFB in San Antonio, Texas. Chain-of-custody data are presented in Appendix P. Method detection limits and analytical methods used are presented in Table 4.2-1.

The analytical technique of gas chromatography (GC) is based on the principle of separation of a solution's components as they are carried through a column and bind to a stationary phase with different affinities. The separations are based on the differences in migration rates among the sample components, based on the physical characteristics of the components and column. The components can be identified based on their retention time, the time required for the component to elude from the column, as compared to the standard solutions. The standards contain known concentrations of the analytes of interest.

Table 4.2-1. Analytical Methods and Detection Limits

Parameter	Water Method	Water Units	Water Detection Limit	Soil and Sediment Method	Soil and Sediment Units	Soil and Sediment Detection Limit
Purgeable Organics						
Benzene	EPA 602	µg/L	0.20	SW846#8240	mg/kg	0.23
Bromodichloromethane	EPA 601	µg/L	0.10	SW846#8240	mg/kg	0.12
Bromoform	EPA 601	µg/L	0.20	SW846#8240	mg/kg	0.26
Bromomethane	EPA 601	µg/L	1.18	SW846#8240	mg/kg	0.32
Carbon Tetrachloride	EPA 601	µg/L	0.12	SW846#8240	mg/kg	0.15
Chlorobenzene	EPA 601	µg/L	0.25	SW846#8240	mg/kg	0.33
Chloroethane	EPA 601	µg/L	0.52	SW846#8240	mg/kg	0.45
2-Chloroethylvinyl Ether	EPA 601	µg/L	0.13	SW846#8240	mg/kg	0.55
Chloroform	EPA 601	µg/L	0.05	SW846#8240	mg/kg	0.085
Chloromethane	EPA 601	µg/L	0.08	SW846#8240	mg/kg	0.23
Dibromochloromethane	EPA 601	µg/L	0.09	SW846#8240	mg/kg	0.17
1,1-Dichloroethane	EPA 601	µg/L	0.07	SW846#8240	mg/kg	0.26
1,2-Dichloroethane	EPA 601	µg/L	0.03	SW846#8240	mg/kg	0.15
1,1-Dichloroethene	EPA 601	µg/L	0.13	SW846#8240	mg/kg	0.17
trans-1,2-Dichloroethene	EPA 601	µg/L	0.10	SW846#8240	mg/kg	0.087
1,2-Dichloropropane	EPA 601	µg/L	0.04	SW846#8240	mg/kg	0.33
cis-1,3-Dichloropropene	EPA 601	µg/L	0.34	SW846#8240	mg/kg	0.27
trans-1,3-Dichloropropene	EPA 601	µg/L	0.20	SW846#8240	mg/kg	0.35
Ethylbenzene	EPA 602	µg/L	0.20	SW846#8240	mg/kg	0.36
Methylene Chloride	EPA 601	µg/L	0.25	SW846#8240	mg/kg	0.15
1,1,2,2-Tetrachloroethane	EPA 601	µg/L	0.03	SW846#8240	mg/kg	0.22
Tetrachloroethene	EPA 601	µg/L	0.03	SW846#8240	mg/kg	0.22
Toluene	EPA 602	µg/L	0.20	SW846#8240	mg/kg	0.32
1,1,1-Trichloroethane	EPA 601	µg/L	0.03	SW846#8240	mg/kg	0.21
1,1,2-Trichloroethane	EPA 601	µg/L	0.02	SW846#8240	mg/kg	0.27
Trichloroethene	EPA 601	µg/L	0.12	SW846#8240	mg/kg	0.10
Trichlorofluoromethane	EPA 601	µg/L	0.05	SW846#8240	mg/kg	0.17
Vinyl Chloride	EPA 601	µg/L	0.18	SW846#8240	mg/kg	0.27
Xylene (ortho, meta, para)	EPA 602	µg/L	0.50	SW846#8240	mg/kg	0.32
Base/Neutral Extractables						
Acenaphthene	EPA 625	µg/L	1.9			
Acenaphthylene	EPA 625	µg/L	3.5			
Anthracene	EPA 625	µg/L	1.9			
Aldrin	EPA 625	µg/L	1.9			
Benzo(a)anthracene	EPA 625	µg/L	7.8			
Benzo(b)fluoranthene	EPA 625	µg/L	4.8			
Benzo(k)fluoranthene	EPA 625	µg/L	2.5			
Benzo(a)pyrene	EPA 625	µg/L	2.5			
Benzo(ghi)perylene	EPA 625	µg/L	4.1			

Table 4.2-1. Analytical Methods and Detection Limits

Parameter	Water Method	Water Units	Water Detection Limit
Base/Neutral Extractables (Cont.)			
Benzyl Butyl Phthalate	EPA 625	µg/L	2.5
b-BHC	EPA 625	µg/L	4.2
g-BHC	EPA 625	µg/L	3.1
bis(2-Chloroethyl)ether	EPA 625	µg/L	5.7
bis(2-Chloroethoxy)methane	EPA 625	µg/L	5.3
bis(2-ethylhexyl)phthalate	EPA 625	µg/L	2.5
bis(2-chloroisopropyl)ether	EPA 625	µg/L	5.7
4-Bromophenyl Phenyl Ether	EPA 625	µg/L	1.9
Chlordane	EPA 625	µg/L	5.1
2-Chloronaphthalene	EPA 625	µg/L	1.9
4-Chlorophenyl Phenyl Ether	EPA 625	µg/L	4.2
Chrysene	EPA 625	µg/L	2.5
4,4'-DDD	EPA 625	µg/L	2.8
4,4'-DDE	EPA 625	µg/L	5.6
4,4'-DDT	EPA 625	µg/L	4.7
Dibenzo(a,h)Anthracene	EPA 625	µg/L	2.5
Di-N-Butylphthalate	EPA 625	µg/L	2.5
1,2-Dichlorobenzene	EPA 625	µg/L	1.9
1,3-Dichlorobenzene	EPA 625	µg/L	1.9
1,4-Dichlorobenzene	EPA 625	µg/L	4.4
3,3'-Dichlorobenzidine	EPA 625	µg/L	16.5
Dieldrin	EPA 625	µg/L	2.5
Diethyl Phthalate	EPA 625	µg/L	1.9
Dimethyl Phthalate	EPA 625	µg/L	1.9
2,4-Dinitrotoluene	EPA 625	µg/L	5.7
2,6-Dinitrotoluene	EPA 625	µg/L	1.9
Di-N-Octyl Phthalate	EPA 625	µg/L	2.5
Endosulfan Sulfate	EPA 625	µg/L	5.6
Endrin Aldehyde	EPA 625	µg/L	7.6
Fluoranthene	EPA 625	µg/L	2.2
Fluorene	EPA 625	µg/L	1.9
Heptachlor	EPA 625	µg/L	1.9
Heptachlor Epoxide	EPA 625	µg/L	2.2
Hexachlorobenzene	EPA 625	µg/L	1.9
Hexachlorobutadiene	EPA 625	µg/L	0.9
Hexachloroethane	EPA 625	µg/L	1.6
Indeno(1,2,3-c,d)Pyrene	EPA 625	µg/L	3.7
Isophorone	EPA 625	µg/L	2.2

Table 4.2-1. Analytical Methods and Detection Limits

Parameter	Water Method	Water Units	Water Detection Limit	Soil and Sediment Method	Soil and Sediment Units	Soil and Sediment Detection Limit
<u>Base/Neutral Extractables</u> (Cont.)						
Naphthalene	EPA 625	µg/L	1.6			
Nitrobenzene	EPA 625	µg/L	1.9			
N-Nitrosodi-N-Propylamine	EPA 625	µg/L	30			
PCB-1016	EPA 625	µg/L	30			
PCB-1221	EPA 625	µg/L	30			
PCB-1232	EPA 625	µg/L	30			
PCB-1242	EPA 625	µg/L	30			
PCB-1248	EPA 625	µg/L	30			
PCB-1254	EPA 625	µg/L	36			
PCB-1260	EPA 625	µg/L	40			
Phenanthrene	EPA 625	µg/L	5.4			
Pyrene	EPA 625	µg/L	1.9			
Toxaphene	EPA 625	µg/L	60			
1,2,4-Trichlorobenzene	EPA 625	µg/L	1.9			
<u>Acid Extractables</u>						
4-Chloro-3-Methyphenol	EPA 604	µg/L	0.36			
2-Chlorophenol	EPA 604	µg/L	0.31			
2,4-Dichlorophenol	EPA 604	µg/L	0.39			
2,4-Dimethylphenol	EPA 604	µg/L	0.32			
2,4-Dinitrophenol	EPA 604	µg/L	13.0			
2-Methyl-4,6-Dinitrophenol	EPA 604	µg/L	16.0			
2-Nitrophenol	EPA 604	µg/L	0.45			
4-Nitrophenol	EPA 604	µg/L	2.8			
Pentachlorophenol	EPA 604	µg/L	7.4			
Phenol	EPA 604	µg/L	0.14			
2,4,6-Trichlorophenol	EPA 604	µg/L	0.67			
<u>Metals</u>						
Antimony	EPA 200.7	mg/L	0.060			
Arsenic	EPA 200.7	mg/L	0.060			
Beryllium	EPA 200.7	mg/L	0.0010			
Cadmium	EPA 200.7	mg/L	0.0080			
Chromium	EPA 200.7	mg/L	0.0060			
Copper	EPA 200.7	mg/L	0.0060			
Lead	EPA 239.2	mg/L	0.050	SW7421	mg/kg	0.50
Mercury	EPA 245.1	mg/L	0.0002			

Table 4.2-1. Analytical Methods and Detection Limits

Parameter	Water			Soil and Sediment		
	Method	Units	Detection Limit	Method	Units	Detection Limit
Metals (Cont.)						
Nickel	EPA 200.7	mg/L	0.0150			
Selenium	EPA 200.7	mg/L	0.090			
Silver	EPA 200.7	mg/L	0.007			
Thallium	EPA 200.7	mg/L	0.10			
Zinc	EPA 200.7	mg/L	0.0030			
Petroleum Hydrocarbons	EPA 418.1	mg/L	0.09	SW3540 E418.1	mg/kg	50
1,2-Dibromoethane (EDB)	EPA 502.1	µg/L	0.010			
EP Toxicity						
Endrin				SW1310	ug/L	0.133
Lindane				SW1310	ug/L	0.066
Methoxychlor				SW1310	ug/L	0.347
Toxaphene				SW1310	ug/L	1.57
2,4-D, Total				SW1310	ug/L	0.222
2,4,5-TP/Silvex				SW1310	ug/L	0.056
Cadmium, Dissolved				SW1310	mg/L	0.0047
Chromium, Dissolved				SW1310	mg/L	0.019
Lead, Dissolved				SW1310	mg/L	0.033
Silver, Dissolved				SW1310	mg/L	0.0059
Arsenic, Dissolved				SW1310	mg/L	0.060
Mercury, Dissolved				SW1310	mg/L	0.0002
Selenium, Dissolved				SW1310	mg/L	0.0042
Barium, Dissolved				SW1310	mg/L	0.010

Source: ESE, 1988.

All analyses were conducted using ESE's standard Quality Assurance/ Quality Control (QA/QC) procedures (see Appendix D). In addition, 10 percent blind duplicate Quality Control (QC) samples were collected in the field and analyzed by the ESE laboratory. Samples with "hits" on the primary column require second column confirmation. Second column confirmation involves analyzing the standards and samples on a GC equipped with a different column. The retention times are different for the primary and secondary columns. An analyte that is identified on both columns is a confirmed "hit." The sample may, however, contain non-target compounds that have the same retention time as the target compounds. This interference may prevent the confirmation of the analyte on the secondary column. The exact definition of which non-target compounds are responsible for the interference is not possible.

Second-column confirmation was provided for all GC methods. Confirmation of all positive concentrations was provided by second-column GC, with results of the first column used for quantification. If the presence of a contaminant could not be confirmed by the second-column results, the parameter was reported as not confirmed. Quantification of detectable contaminants was based on first-column results. All analytical results presented in this report have been method blank corrected.

A listing of laboratory QC results obtained during this project, including laboratory blanks and spikes, are found in Appendix Q.

4.3 GENERAL DISCUSSION

Results for ground water, surface water, sediment, and soil samples collected during the Phase II, Stage 2 study are presented in Appendix R. These results have been evaluated in terms of relevant state and Federal standards and criteria wherever possible. Parameters for which specific state or Federal standards and criteria are not available are evaluated based primarily on applicable human health drinking water advisories and secondarily on other toxicological data.

The following paragraphs summarize the methods of chemical analysis utilized during the Phase II, Stage 2 investigations at Tyndall AFB.

pH, Temperature, Specific Conductance

All ground water and surface water samples were analyzed for pH, temperature, and specific conductance at the time of collection. A Hydrolab® portable field unit was used for taking measurements following field calibrations at the beginning of each field day.

Metals

Chemical analyses were performed for 13 priority pollutant metals. All the metals, with the exception of lead and mercury, were analyzed by Inductively Coupled Plasma (ICP) spectroscopy (EPA Method 200.7). Analysis of lead and mercury were by atomic absorption spectrophotometry. All metals were analyzed for total metals following acid digestion of the samples.

Total Recoverable Petroleum Hydrocarbons

The oil and grease analysis by EPA Method 413.2 (EPA, 1983) does not differentiate between extractables of biological origin or the mineral oils and greases of POL origin; therefore, the EPA Infrared (IR) Spectrophotometric Method for total recoverable petroleum hydrocarbons (TRPH) (EPA Method 418.1) was used for assessing petroleum contamination.

Purgeable Organics

Purgeable halocarbons were determined by EPA Method 601. Purgeable aromatic compounds were determined by EPA Method 602. Both methods are purge-and-trap GC techniques for the determination of purgeable organics.

Base/Neutral Extractable Organics

Base/neutral extractable organics were analyzed by EPA Method 625, a gas chromatographic/mass spectrometer (GC/MS) technique utilizing a liquid-liquid extraction with methylene chloride.

Acid Extractable Organics

Acid extractable organics were analyzed by EPA Method 604, a GC technique utilizing liquid-liquid extraction with methylene chloride. Acid extractable organics were also analyzed along with base/neutral organics at Zones 7 and 8 by EPA Method 625.

Second-column confirmation was performed for all compounds identified by GC. During second column confirmation, an alloquot of sample that has been found to contain specific compounds is reanalyzed. This procedure is carried out to verify the results obtained during the first analysis. The need for second-column confirmation is based on the principles of the GC technique. GC analysis is based on the principle of separation of a sample's components by means of differing retention times as the sample is passed through a column. As a sample is passed through a column, the various components in the sample bind to the stationary phase of the column with differing affinities. The end result is the individual components of the sample elute from the column at different times. The compounds can then be identified based on the known retention times of various target compounds. However, retention times for various compounds are not unique, with the result that non-target compounds can elute at the same retention time as target compounds. The lack of unique retention times can complicate positive identification of target compounds. A different type of column, with different retention times is used during the second column confirmation. The different retention times on the two columns helps to confirm the presence of specific compounds in a sample.

EDB

EDB was analyzed by EPA Method 502.1, which is also a GC technique using a liquid-liquid extraction with hexane.

4.3.1 ZONE 2--LYNN HAVEN DFSP

Zone 2 is located adjacent to North Bay (see Fig. 4.3-1) and has been used as a bulk fuel storage and dispensing terminal since 1943. Although the property is owned by Tyndall AFB, the facility was acquired by the Defense Fuel Supply Center in 1973 and is operated by a private contractor. In the past, bunker C fuel from cleaning waste drums was routinely dumped on the ground near a drum loading station, originally located south of the railcar loading area. Bunker C fuel was also reportedly pumped out on the ground outside the west gate of the facility when this type of fuel was phased out. Moderate quantities may have been disposed of in this manner. Prior to 1969, it was common practice to bury tank sludges containing JP-4 and JP-5 within diked areas surrounding the storage tanks. Some of the sludges were from leaded fuel. Locations and quantities of buried material were not recorded. Most of the buried material is believed to have been removed during regrading and resurfacing of the terminal grounds. Reports of minor spills at Zone 2 have been common.

Two downgradient monitor wells (LH2-8 and LH2-9) were installed at Zone 2 to replace wells which were originally installed during the Phase II, Stage 1 study. The sediments underlying Zone 2 generally consisted of unconsolidated clean sands and silty sands through the depths penetrated (see Fig. 4.3-2). The upper 8 to 10 ft of sediments was comprised of fine- to medium-grained, poorly graded quartz sand, with trace occurrences of silt and organic material. Under these surficial deposits, the sediments graded to silty sands. These silty sands were generally fine- to medium-grained, poorly to moderately graded, and composed predominantly of quartz, with silt content ranging from 10 to 25 percent. The silt and organic component caused dark gray to dark brown coloration of this lower unit, which extended to the base of the deeper boreholes.

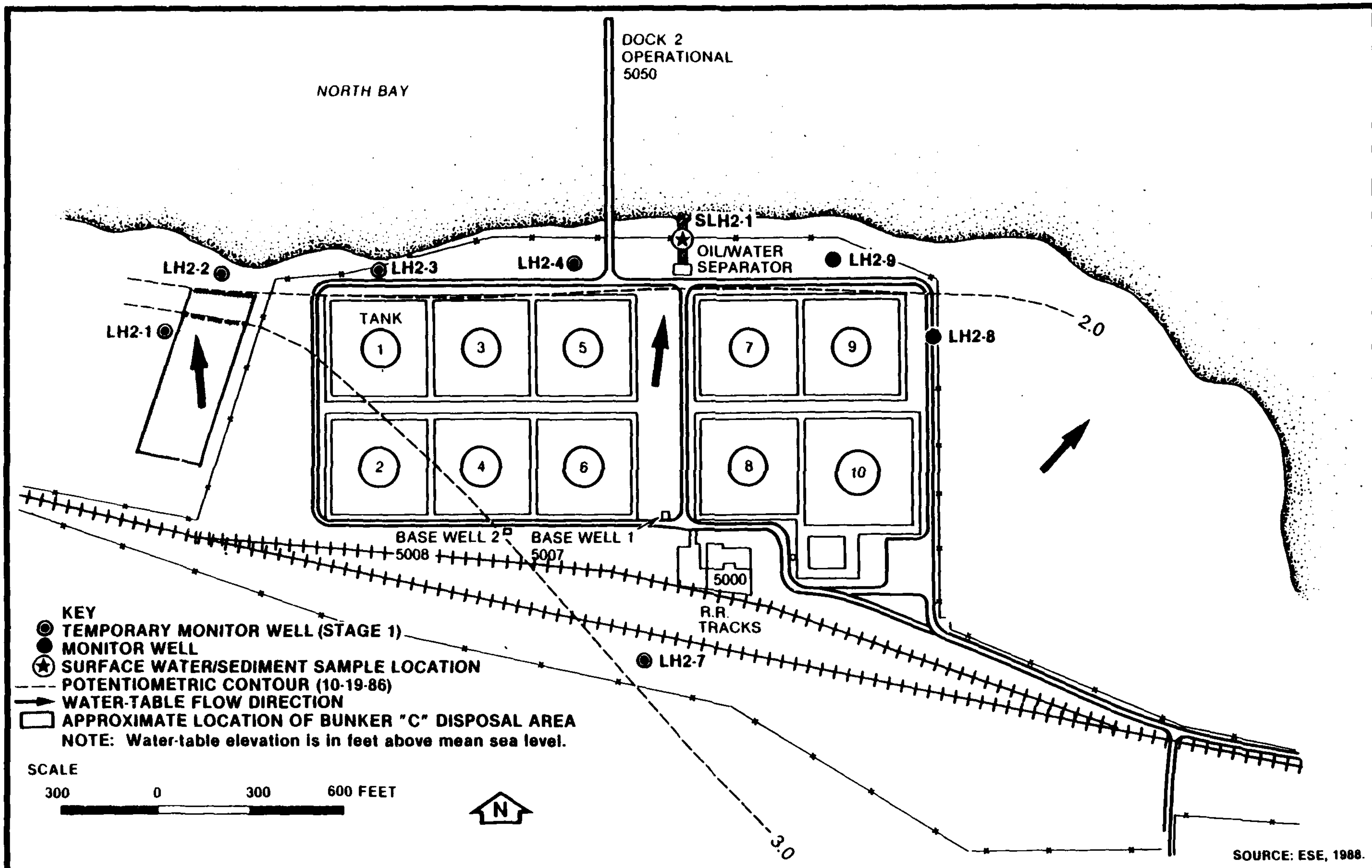

Figure 4.3-1
SITE MAP FOR ZONE 2 — LYNN HAVEN DFSP

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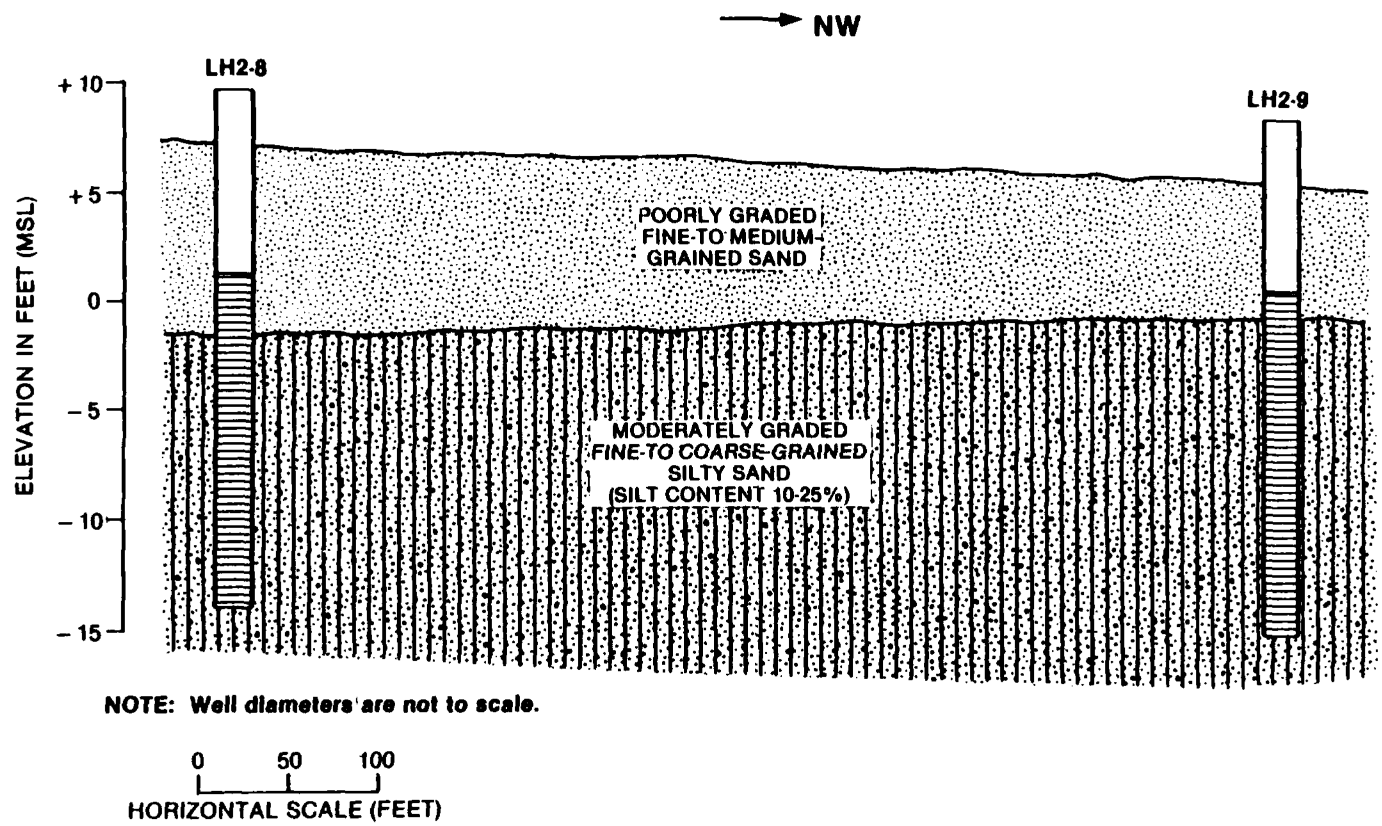

SOURCE: ESE, 1988.

Figure 4.3-2
ZONE 2 — SHALLOW GEOLOGIC CROSS SECTION

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Water-table levels ranged from 1.5 to 3.7 ft above sea level at Zone 2. The potentiometric surface of the shallow aquifer is shown in Fig. 4.3-1. Ground water flow direction was to the north and northwest, eventually discharging into North Bay. Recharge to wells adjacent to North Bay (LH2-2, LH2-3, LH2-4) was slow, requiring discontinuous pumping during development and purging. This was a function of their lower ground elevation; therefore, the screened interval was dominantly in the lower silty sand unit. Wells LH-1, LH-7, and LH-8 pumped continuously at rates ranging from 1.4 to 3.3 gpm.

A total of seven ground water monitor wells (two new and five existing) were sampled at Zone 2. Wells LH2-1 and LH2-2 were located downgradient and crossgradient of the disposal site outside the west gate (Fig. 4.3-1). Wells LH2-3, LH2-4, LH2-8, and LH2-9 were located downgradient of the storage tank area, close to North Bay. Well LH2-7 was located south of the storage tank area near the railcar loading area.

Detectable concentrations of various analytes found in surface water, ground water, and sediment samples collected at Zone 2 are presented in Table 4.3-1.

Ground water samples were analyzed for pH, specific conductance, purgeable organics, petroleum hydrocarbons, and lead. The pH values in ground water at this site ranged from 5.7 to 7.0. NSDW regulations specify that acceptable pH values should range between 6.5 and 8.5, unless affected by natural conditions. A comparison of pH values at Zone 2 with values from other locations on Tyndall AFB indicate the shallow ground water on Tyndall AFB tends to be acidic with naturally occurring pH values below 6.5. Very limited information exists on background water quality in the surficial aquifer in the Tyndall AFB area. The Northwest Florida Water Management District has sampled a well in the surficial aquifer at Cedar Grove. Data from this well shows a pH of 5.5 and a specific conductance of 168 micromhos per centimeter (μmhos/cm) (Clemens, Personal Communication).

Table 4.3-1. Analytical Results for Ground Water, Surface Water, and Sediment Samples with Detectable Levels of Contaminants from Zone 2

Parameter	Ground Water								Detection Limits	NPWDR MCL	Surface Water	Sediments (mg/kg)
	LH2-1	LH2-2	LH2-3	LH2-4	LH2-7	LH2-8	LH2-9	LH2-9+			SW2-1	SO2-1
ph field (standard units)	5.70	5.60	7.00	6.90	5.70	6.00	5.70	NA			7.10	NA
Specific conductance (umhos/cm)	143	58.0	352	261	237	330	293	NA			1,370	NA
Trichlorofluoromethane (ug/L)	ND	ND	ND	0.10	ND	ND	ND	NA	0.050		ND	<0.28
Methylene chloride (ug/L)	ND	ND	ND	0.095	ND	ND	ND	NA	0.050		ND	<0.25
Chloromethane (ug/L)	ND	ND	ND	ND	ND	1.4*	ND	NA	0.050		ND	<0.38
Ethylbenzene (ug/L)	ND	ND	ND	ND	ND	ND	2.0*	NA	0.50		ND	<0.64
Benzene (ug/L)	ND	ND	ND	ND	ND	ND	ND	NA	0.50	5(1)	0.54	<0.39
Toluene (ug/L)	ND	ND	ND	ND	ND	ND	ND	NA	0.50		0.80	<0.53
Petroleum Hydrocarbons (mg/L)	0.15	0.09	0.78	ND	0.11	ND	0.12	0.16	0.09		4.2**	35,000
Lead (mg/L)	0.0086	ND	ND	ND	0.0043	ND	ND	ND	0.0031	0.050 (0.050)	ND	98

Notes: NA = not analyzed.
ND = not detected.
A complete list of analytical results for Zone 2 is presented in Appendix R.
All other parameters analyzed at Zone 2 were below analytical detection limits.
Values in parentheses are State of Florida MCLs.

*Single-column quantification, unable to confirm by second column due to interference.
+Field duplicate.
**Matrix interference, recovery of sample matrix spike = 22%.

Source: ESE, 1988.

Specific conductance values for ground water at Zone 2 ranged from 58.0 to 352 μmhos/cm. These values appear to be representative of natural background conditions in the Bay County area.

Two volatile halogenated organic compounds were detected and confirmed in ground water samples from Zone 2. Low levels of methylene chloride (0.095 μg/L) and trichlorofluoromethane (freon) (0.10 μg/L) were present in a sample from Well LH2-4. There are currently no MCLs for either compound; however, methylene chloride was well below the EPA ambient water quality criterion for the protection of human health for carcinogenicity. Methylene chloride is used in the laboratory as an extraction solvent and can be present in samples as an artifact. Since the use of halogenated organic compounds has not been reported for Zone 2, it is possible that the low level of methylene chloride detected at Zone 2 is an artifact of sample handling and analysis. Ethylbenzene was detected in Well LH2-9 at a concentration of 2.0 μg/L, which is well below the EPA RMCL for drinking water of 680 μg/L. The presence of ethylbenzene could not be confirmed by second-column analysis due to interfering compounds. Chloromethane was detected in Well LH2-8 at a concentration of 1.4 μg/L, but could not be confirmed by second-column analysis due to interference (see Sec. 4.2).

Low levels of total petroleum hydrocarbons were present in all monitoring wells at Zone 2 with the exception of Wells LH2-4 and LH-2-8. Concentrations ranged from 0.09 mg/L at Well LH2-2 to 0.78 mg/L at Well LH2-3. There are no state or Federal criteria for total petroleum hydrocarbons in ground water. However, the concentrations of total petroleum hydrocarbons found in ground water samples at Zone 2 were considerably below the State of Florida surface water criterion of 5 mg/L for oil and grease. This indicates little potential for significant contamination of surface water by petroleum hydrocarbon migration.

Low levels of lead were detected in Wells LH2-1 (0.0086 mg/L) and LH2-7 (0.0043 mg/L) and were below the state and NPDWR MCL of 0.050 mg/L. Lead concentrations detected at Zone 2 did not indicate significant contamination from the POL area.

A single surface water and a single sediment sample were collected from a drainage ditch leading from an oil/water separator to North Bay. These samples were analyzed for pH, specific conductance, purgeable organics, petroleum hydrocarbons, and lead.

The pH of the surface water sample was 7.10, well within the State of Florida criteria for Class II surface waters. The specific conductance of the surface water sample was 1,370 umhos/cm, which reflected the saline influence of North Bay on the drainage ditch.

There were no volatile organic compounds detected in the sediment sample. Two volatile organic compounds were detected in the surface water sample. Detectable levels of benzene (0.54 µg/L) and toluene (0.80 µg/L) were confirmed in the surface water sample. The concentration of benzene was below the EPA ambient water quality criterion of 40 µg/L for the protection of human health for ingestion of aquatic organisms only, as well as the proposed EPA chronic ambient water quality criteria for the protection of saltwater aquatic life. Toluene was also below the ambient water quality criteria of 424,000 µg/L for the protection of human health for toxicity for ingestion of organisms only, and the lowest reported chronic toxicity level for saltwater aquatic life of 5,000 µg/L. Total petroleum hydrocarbons were detected in the surface water sample at a concentration of 4.2 mg/L. This concentration was below the 5.0-mg/L state criterion for oil and grease in Class II surface waters. The sediment sample from Zone 2 contained 35,000 mg/kg of total petroleum hydrocarbons. The lead concentration detected in the sediment sample was 98 milligrams per kilogram (mg/kg). Currently, there are no state or

Federal criteria for contaminants in sediments. Compared to lead concentrations detected in sediment samples from Zone 11 (3.2 to 5.1 mg/kg), the lead concentration in the sediment sample from Zone 2 was significantly higher. The elevated lead and total petroleum hydrocarbons concentration detected in the sediment sample from Zone 2 may have been the result of discharge from the oil/water separator.

Significant Findings

Results of analysis of ground water and surface water samples from this site show low levels of petroleum related contamination. Sediment samples collected from the drainage ditch leading from the oil/water separator to North Bay contained elevated concentrations of lead (98 mg/kg) and total petroleum hydrocarbons (35,000 mg/kg). However, the concentration of total petroleum hydrocarbons in the surface water sample from the drainage ditch was below the state Class II water quality criterion of 5 mg/L for oil and grease. Lead was not detected in the surface water sample.

Surface water in the drainage ditch leading from the oil/water separator contained low levels of benzene (0.54 μg/L) and toluene (0.80 μg/L), both of which were below the EPA ambient water quality criteria for the protection of saltwater aquatic life.

Two halogenated volatile organic compounds were found in ground water samples from this zone. Both compounds were detected at low concentrations.

Lead and total petroleum hydrocarbons were also detected in ground water samples. Lead concentrations were low and not indicative of contamination. All lead concentrations were below the state and NPDWR MCL of 0.050 mg/L.

Results of the investigation carried out at Zone 2 showed low levels of petroleum-related contaminants in the surficial aquifer. It is likely that the majority of petroleum disposed at Zone 2 has undergone degradation and is not migrating offsite. Since the surficial aquifer is not used as a potable water source, an imminent human health hazard from the consumption of contaminated ground water does not appear to exist at Zone 2.

4.3.2 ZONE 3--POL AREA A

Zone 3 is located at the tank farm near the Shoal Point Bayou unloading facilities (Fig. 4.3-3). Small quantities of residues from tank sludge removal operations have been routinely disposed into shallow trenches at this site since 1943. Prior to 1974, AVGAS (containing lead) was commonly stored at the POL Area A tank farm. Sludges from tanks containing AVGAS would have contained lead. The results of the Phase II, Stage 1 studies at Zone 3 showed detectable levels of TOX ranging from 90 to 140 µg/L. Analysis ot specific purgeable organic compounds resulted in the identification of low levels of chloroform, 1,1-dichloroethene, methylene chloride, and 1,1,1-trichloroethane. Lead was also detected during the Phase II, Stage 1 study at a level of 0.034 mg/L in Well T3-3.

As part of the Phase II, Stage 2 studies at Tyndall AFB, one upgradient monitor well (T3-7) and two downgradient monitor wells (T3-5 and T3-6) were installed at Zone 3 to supplement four existing monitor wells (Fig. 4.3-3). Water-table gradient data from the site indicated that the four existing wells were located outside of or oblique to the potential contaminant migration path.

The sediments underlying Zone 3 generally consisted of unconsolidated sands and silty sands with traces of organic material through the depth penetrated (see Fig. 4.3-4). Borehole descriptions from the Phase II, Stage 1 report (Thiess _et al._, 1984) indicate the upper 11.5 ft at Wells T3-1 and T3-4 was composed of very fine- to medium-grained quartz sand

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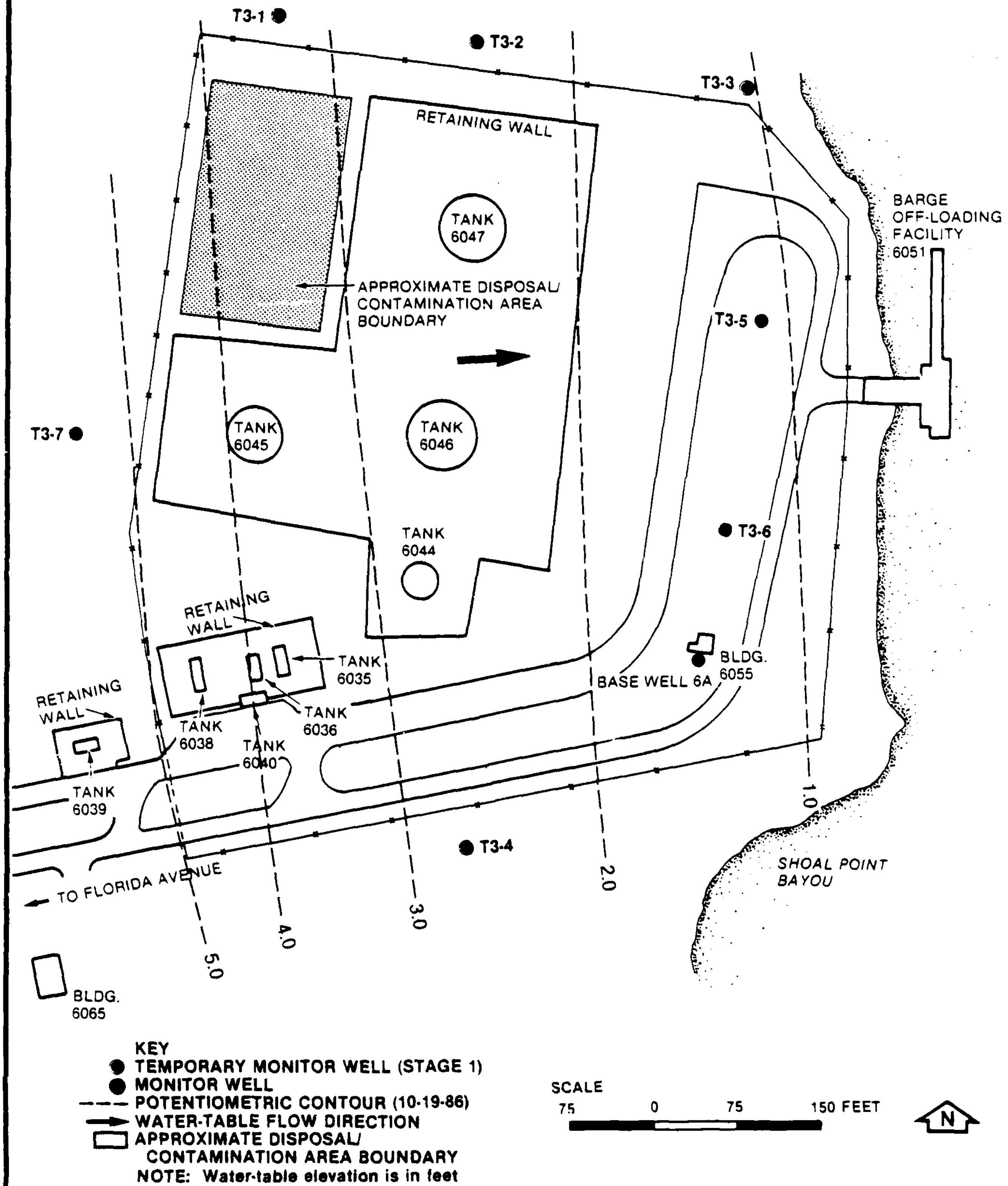

SOURCE: ESE. 1988.

Figure 4.3-3
SITE MAP FOR ZONE 3—
POL AREA A

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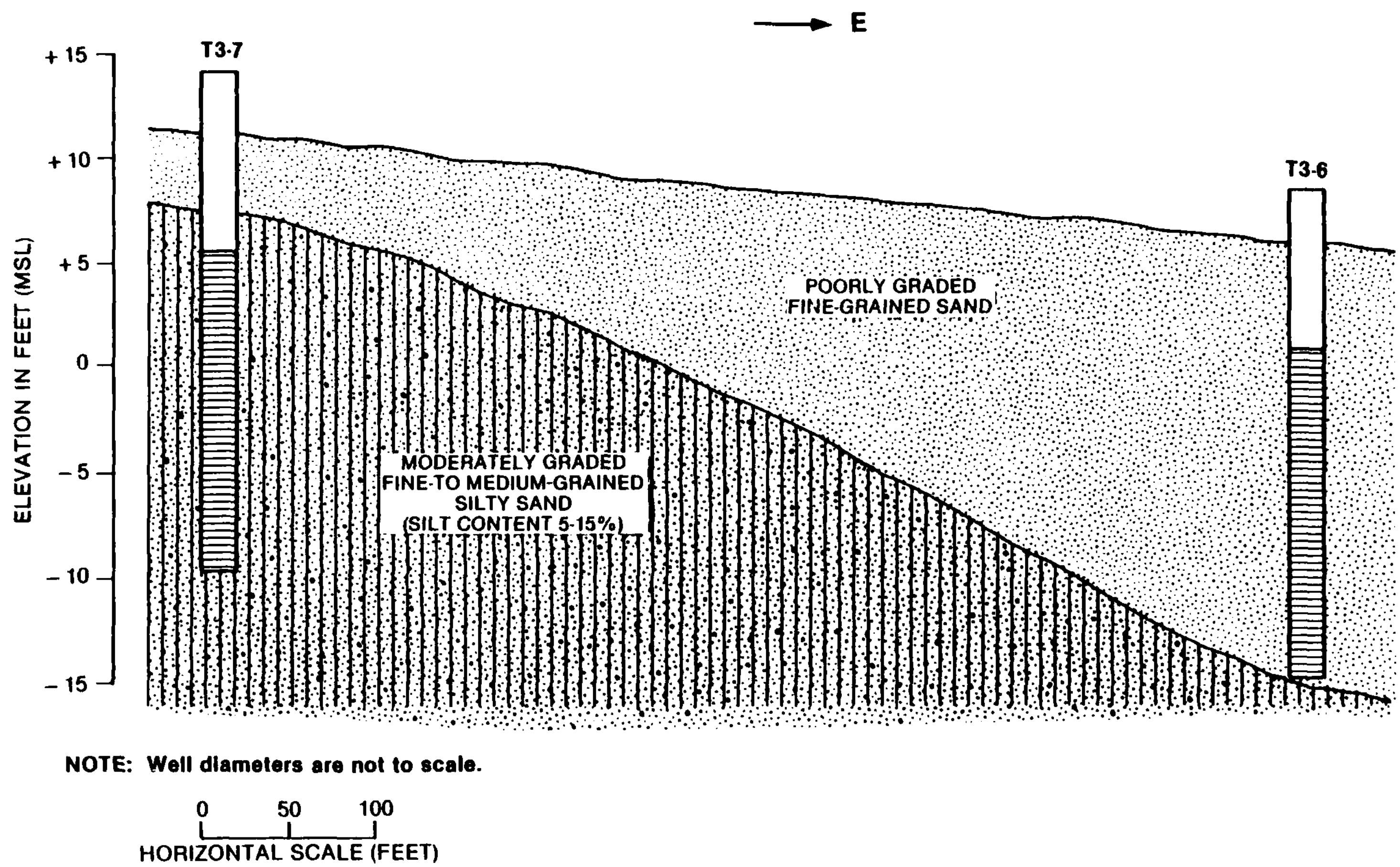

SOURCE: ESE, 1988.

Figure 4.3-4
ZONE 3 — SHALLOW GEOLOGIC CROSS SECTION

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with traces of silt, organic material, and heavy minerals. Borehole descriptions from monitor wells installed during this study indicate clean, very fine- to fine-grained, poorly graded quartz sands were encountered in both downgradient wells (T3-5 and T3-6), and minor occurrences of silt were present in thin horizons near the surface. The upgradient well (T3-7) was composed of clean, fine-grained poorly graded quartz sands in the upper 3.5 ft, which were underlain by silty sand to the base of the borehole. These silty sands were generally fine- to medium-grained, poorly to moderately graded, with increased silt content downward. This silty unit ranged from light brown to dark brown in color.

Water-table elevations ranged from 1.0 to 5.6 ft above sea level, with the elevation of the potentiometric surface of the shallow aquifer mapped in Fig. 4.3-3. Direction of ground water flow was to the east, with discharge entering Shoal Point Bayou. Recharge to wells during development and purging was generally sufficient to allow continuous pumpage, with the exception of upgradient Wells T3-4 and T3-7, where lithologies were dominantly silty sands. Downgradient wells (T3-3, T3-5, and T3-6) produced at rates in excess of 10 gpm.

A total of seven monitor wells (three new and four existing) were sampled at Zone 3. Wells T3-5, T3-3, and T3-6 were located downgradient of the tank farm near Shoal Point Bayou. Wells T3-1 and T3-2 were located along the north side of the site, whereas Well T3-4 was located south of the facility. Well T3-7 was located west of POL Area A, upgradient of the suspected area of contamination.

Ground water samples were analyzed for pH, specific conductance, volatile organic compounds, ethylene dibromide (EDB), petroleum hydrocarbons, and lead. Detectable concentrations of various analytes found in ground water samples at Zone 3 are presented in Table 4.3-2.

Table 4.3-2. Analytical Results for Ground Water Samples with Detectable Levels of Contaminants from Zone 3

Parameter	Ground Water								Detection Limits	NPDWR MCLs
	T3-1	T3-2	T3-3	T3-4	T3-5	T3-5+	T3-6	T3-7		
pH field (Standard Units)	6.00	6.00	6.20	6.60	6.10		6.4	5.4		
Specific Conductance (umhos/cm)	144	167	183	320	308		330	74.0		
Bromodichloromethane (ug/L)	ND	ND	ND	ND	0.050	0.080	ND	ND	0.050	100(100)
Chloroform (ug/L)	ND	ND	ND	ND	0.43	0.48	ND	ND	0.050	100(100)
Chloromethane (ug/L)	ND	0.050	ND	ND	ND	ND	ND	ND	0.050	
Methylene Chloride (ug/L)	ND	0.20	ND	ND	ND	ND	ND	ND	0.050	
Trichlorofluoromethane (ug/L)	ND	ND	ND	ND	ND	0.050*	0.090	ND	0.050	
Ethylbenzene (ug/L)	ND	ND	ND	ND	1.6*	0.56*	ND	ND	0.50	
Toluene (ug/L)	ND	ND	ND	ND	3.7	ND	ND	ND	0.50	
Petroleum Hydrocarbons (mg/L)	0.16	ND	ND	ND	0.19	ND	ND	ND	0.10	
Lead (mg/L)	0.014	0.024	0.17	0.025	ND	ND	0.027	0.015	0.0031	0.050 (0.050)

Notes: NA = not analyzed.
ND = not detected.
All other parameters analyzed at Zone 3 were below analytical detection limits.
Complete analytical results for Zone 3 are presented in Appendix R.
Values in parentheses are State of Florida MCLs.
Analyses for volatile organic compounds for each sample T3-5+ exceeded the EPA holding time of 14 days by 2 days.

*Single column quantification, unable to confirm by second column due to interference.
+Field duplicate.

Source: ESE, 1988.

The pH values at Zone 3 ranged from 5.4 to 6.6. These values were typical of the conditions observed for water in the surficial aquifer throughout Tyndall AFB. Specific conductance values (74.0 to 330 μmhos/cm) were also within natural background levels found at Tyndall AFB.

Six volatile organic compounds were detected in the surficial aquifer at Zone 3. Ethylbenzene was also detected, but could not be confirmed by second-column analysis due to interference (see Section 4.2). Bromodichloromethane and chloroform were detected in the downgradient Well T3-5 at concentrations of 0.50 and 0.43 μg/L, respectively. Both compounds were present at levels below the state and NPDWR MCL of 100 μg/L for total THMs. Chloromethane and methylene chloride were both present in Well T3-2 at concentrations of 0.050 and 0.20 μg/L, respectively. The EPA ambient water quality criteria for the protection of human health for carcinogenicity for both compounds is 0.19 μg/L, with only methylene chloride slightly exceeding the EPA ambient water quality criteria. As previously noted, methylene chloride is used in the laboratory as an extraction solvent and is known to be a common artifact in analytical samples. Trichlorofluoromethane (freon) was present at Well T3-6 at a concentration of 0.090 μg/L, which is very near the analytical detection limit of 0.050 μg/L and well below the EPA lifetime reference dose for drinking water of 10,000 μg/L. Toluene was present in Well T3-5 at a level of 3.7 μg/L, well below the proposed EPA RMCL for toluene of 2,000 μg/L. EDB was not detected at Zone 3.

Total petroleum hydrocarbons were detected in Wells T3-1 and T3-5 at levels of 0.16 and 0.19 mg/L, respectively. These concentrations are below the state water quality criterion for oil and grease of 5 mg/L for Class II surface waters.

Lead was present in the surficial aquifer at Zone 3 at concentrations ranging from 0.014 to 0.17 mg/L. All detectable levels of lead were below the NPDWR and state MCL of 0.050 mg/L with the exception of

Well T3-3, which had a lead concentration of 0.17 mg/L. The water sample collected from T3-3 was noted to contain visible particulate matter which may have effected the reported lead concentration for this well.

Significant Findings

Detectable levels of six volatile organic compounds were confirmed in water samples from the surficial aquifer with only methylene chloride slightly exceeding the EPA ambient water quality criteria for the protection of human health. All other organic compounds were below their respective criteria. Due to the low concentration of methylene chloride (0.20 µg/L), and the extensive use of this compound in the laboratory, it is possible that the reported level was primarily an artifact and does not represent significant contamination in the surficial aquifer. Lead was detected in all wells with the exception of T3-5. Lead concentrations were below the NPDWR and state MCL of 0.050 mg/L in all wells with the exception of T3-3. The lead concentration detected at Well T3-3 (0.17 mg/L) is likely the result of past leaded-fuel sludge disposal practices. Lead concentrations in all monitor wells, with the exception of Well T3-3, were low and not representative of significant contamination.

Results of the ground water sampling program show only minor POL-related contamination in the surficial aquifer. Methylene chloride reported for Well T3-2, was likely an analytical artifact. Other volatile organic compounds reported for this site were detected at low levels. The origin of the volatile organic compounds reported for Zone 3 is unknown based on the reported past uses and practices at this site. However, based on a review of the QC data, including laboratory method blanks for this site, the reported volatile organics cannot be totally dismissed as analytical artifacts. Since lead concentrations in all wells, with the exception of T3-3, were below the NPDWR and state MCL, the extent of lead contamination in the surficial aquifer at Zone 3 appears to be limited in areal extent. However, the possibility does exist for lead contamination north

of T3-3. Because the surficial aquifer is not used as a source of drinking water, an imminent human health hazard resulting from the consumption of contaminated water does not appear to exist at Zone 3. A water supply well (Base Well 6A) is located at Zone 3 but is inactive and is screened at a depth of 316 to 600 ft in the Floridan Aquifer. Analytical results for Well 6A from 1984 obtained from Tyndall AFB personnel show lead to be below the analytical detection limit of 0.020 mg/L (see Appendix B). Similar results from Base Well 10, located a distance of 200 ft from Zone 3, also show lead to be below analytical detection limits.

4.3.3 ZONE 5--SMALL ARMS REPAIR AREA

The Small Arms Repair Area (Zone 5) is located in an open field in the "6000" area (Fig. 4.3-5). This site was discovered during conversations with base personnel subsequent to the Phase I records search. Significant amounts of waste paints and solvents were reported to have been disposed into an open pit. Base personnel indicated that the site was used between 1965 and 1972, although some usage may have occurred prior to that period. Research into the types of processes used in the Small Arms Repair Area (blueing and parkerizing) revealed the potential for selenium contamination at this site.

Results of the Phase II, Stage 1 studies at Zone 5 showed concentrations of TOX ranging from 80 to 120 µg/L. Both chromium and lead were undetected during the Phase II, Stage 1 investigations.

As part of the Phase II, Stage 2 studies at Tyndall AFB, ground water samples from the surficial aquifer were obtained from each of the three existing monitor wells. The three existing wells at Zone 5 were considered sufficient to characterize the ground water at this site. The location of the three wells is depicted in Fig. 4.3-5.

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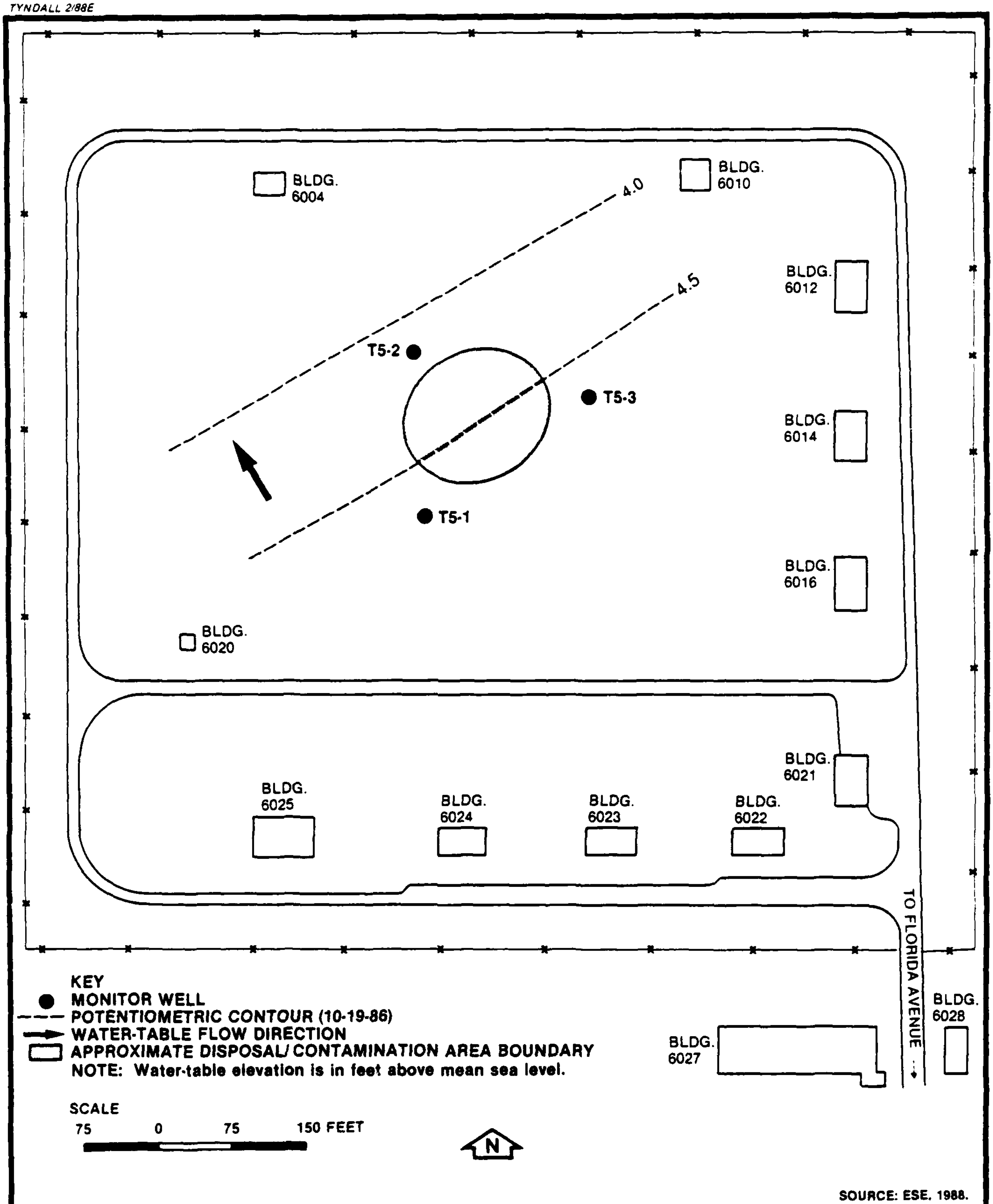

Figure 4.3-5
SITE MAP FOR ZONE 5 — SMALL ARMS REPAIR AREA

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Lithologic descriptions for the sediments underlying Zone 5 were obtained from the Phase II, Stage 1 boring descriptions (Thiess et al., 1984), since no new wells were installed. Sediments were described every 5 ft, with no description provided for the intermittent intervals; therefore, contacts between lithologic units cannot be precisely defined. The sediments underlying Zone 5 generally consisted of unconsolidated, clean sands and silty sands to the depths penetrated. Sediments down to 11.5 ft below ground surface were composed of clean, very fine- to medium-grained, poorly graded quartz sand with traces of silt, clay, and organic material. Samples described from depths of 15.0 to 16.5 ft were composed of sand similar to the overlying sediments but contained 5- to 15-percent silt and clay.

Water-table elevations ranged from 4.1 to 4.6 ft below the ground surface, and the elevation of the potentiometric surface of the shallow aquifer varied by less than 0.5 ft across the site. Ground water flow is to the northwest, but the rate of flow is slow due to the small hydraulic gradient and could vary seasonally as a function of changing precipitation and runoff patterns. The direction of surficial aquifer flow at this site may be influenced by tidal changes due to the small change in topographic variation and proximity to coastal water. Recharge to the wells during purging was sufficient to allow continuous pumping, with well production ranging from 1.7 to 9.1 gpm across the site.

Detectable concentrations of various analytes found in ground water samples at Zone 5 are presented in Table 4.3-3. Ground water samples were analyzed for volatile organics, acid-extractable organics, and priority pollutant metals. The pH values in ground water samples from Zone 5 ranged from 6.0 to 6.4 and were typical of conditions observed in ground water samples at Tyndall AFB. Specific conductance values ranged from 93 to 581 µmhos/cm. Specific conductance at the downgradient Well T5-3 (581 µmhos/cm) was approximately 5 times greater than observed

Table 4.3-3. Analytical Results for Ground Water Samples with Detectable Levels of Contaminants from Zone 5

Parameter	Ground Water				Detection Limits	NPDWR MCL
	T5-1	T5-2	T5-3	T5-3*		
pH field (Standard Units)	6.20	6.00	6.4			
Specific Conductance (umhos/cm)	93	105	581			
Bromodichloromethane (ug/L)	ND	ND	0.070	0.060	0.050	100 (100)
Chloroform (ug/L)	ND	ND	0.44	0.46	0.050	100 (100)
Arsenic Total (mg/L)	0.086	0.63	0.20	NA	0.050	0.050 (0.050)
Beryllium Total (mg/L)	0.014	ND	ND	NA	0.0010	
Chromium Total (mg/L)	0.019	0.054	0.028	NA	0.0060	0.050 (0.050)
Copper Total (mg/L)	0.007	0.019	0.014	NA	0.0060	(1.0)
Nickel Total (mg/L)	ND	0.015	ND	NA	0.015	
Silver Total (mg/L)	ND	ND	0.0065	NA	0.0060	0.050 (0.050)
Thallium Total (mg/L)	ND	0.056	ND	NA	0.037	
Zinc Total (mg/L)	0.009	0.019	0.011	NA	0.0030	(5.0)
Mercury Total (mg/L)	ND	0.0003	ND	NA	0.0002	0.002 (0.002)

Notes: NA = not analyzed.
ND = not detected.
All other parameters analyzed at Zone 5 were below analytical detection limits.
Complete analytical results for Zone 5 are presented in Appendix R.
Values in parentheses are State of Florida MCLs.

*Field duplicates.

Source: ESE, 1988.

in the other two monitoring wells at this zone. It is not clear if the increase in specific conductance at T5-3 is due to localized natural differences in background specific conductance levels, or the result of ground water contamination.

Two volatile halogenated organic compounds were detected at Zone 5. Bromodichloromethane and chloroform were detected and confirmed in Well T5-3 at concentrations of 0.070 and 0.44 μg/L, respectively. Both compounds were found at low levels, below the state and NPDWR MCL of 100 μg/L for total trihalomethanes.

Ground water samples from Zone 5 were analyzed for acid-extractable organics to detect the presence of phenolic paint strippers reportedly disposed into an open pit at this site. Phenolic compounds were below analytical detection limits in all three wells at Zone 5.

A priority pollutant metal scan was conducted on ground water samples from Zone 5 which resulted in the identification of 9 metals with detectable concentrations. Of these, copper, silver, and mercury were present at trace levels below their respective state and NPDWR MCLs. Low levels of zinc were present in all three monitoring wells, below the state MCL of 5.0 mg/L. Nickel was detected at a concentration of 0.015 mg/L in Well T5-2. This concentration is below the EPA lifetime health advisory for nickel of 0.150 mg/L. Currently, no primary or secondary drinking water criteria exist for nickel. Zinc, copper, silver, mercury, and nickel were all detected at trace levels and were not representative of significant contamination. Of the remaining priority pollutant metals detected at Zone 5, arsenic and chromium were both present at levels exceeding state and NPDWR MCLs. Arsenic and chromium were detected in all monitor wells. Concentrations of arsenic ranged from 0.086 mg/L at T5-1 to 0.63 mg/L at T5-2. Chromium concentrations ranged from 0.019 mg/L at T5-1 to 0.054 mg/L at T5-2. With the exception of silver, the highest concentrations of priority pollutant metals at Zone 5 were detected in the downgradient Well T5-2.

Currently, there is no NPDWR or state MCL for thallium. However, the level detected in Well T5-2 (0.056 mg/L) exceeded the EPA ambient water quality criterion of 0.013 mg/L for the protection of human health. The concentration of beryllium in Well T5-1 also exceeded the EPA ambient water quality criterion of 3.7×10^{-6} mg/L for the protection of human health for carcinogenicity. All QC data were reviewed for this site, including laboratory blanks. The results of this review showed all analyses to be free of laboratory artifacts.

Significant Findings

Trace amounts of two volatile halogenated organic compounds (bromodichloromethane and chloroform) were detected in Well T5-3. Both contaminants were below the NPDWR and state MCL for total trihalomethane (THMs) of 100 µg/L and do not represent significant contamination at this site. Phenolic contaminants from waste paint strippers were not detected at Zone 5.

Nine priority pollutant metals were detected, with concentrations of arsenic and chromium exceeding their respective NPDWR and state MCLs. Concentrations of beryllium and thallium at Zone 5 were found to exceed the EPA ambient water quality criteria for the protection of human health. Currently, there are no MCLs for beryllium or thallium. The remaining five metals detected at this zone, copper, silver, zinc, and mercury were detected at trace levels, below their respective MCLs. Nickel was also detected at Zone 5 at a concentration below the EPA health advisory of 0.15 mg/L. Of the nine metals detected at Zone 5, concentrations of nickel, copper, silver, zinc, and mercury were not present at levels indicating significant contamination.

Since the surficial aquifer is not being utilized as a potable source, the contamination at this site does not appear to present an imminent human health hazard from the consumption of contaminated ground water. The limited number of monitor wells (three) included during this study

was not sufficient to fully define the areal or vertical extent of contamination at this site. Both upgradient and downgradient monitor wells were found to contain levels of priority pollutant metals in excess of their state and NPDWR MCLs. Due to the lack of a strong hydraulic gradient in the surficial aquifer at Zone 5, tidal influences may be effecting the direction of ground water flow at this area.

Base water supply Well 5A is located approximately 500 ft downgradient of Zone 5 in the Floridan Aquifer. Well 5A is screened from 435 to 465 ft below ground surface and is currently listed as inactive. Results of a base supply well sampling program conducted by Tyndall AFB in January 1984 (see Appendix B) showed all metal concentrations in Well 5A to be below analytical detection limits with the exception of zinc. Zinc was present at a level below the MCL at 5 mg/L. There are no offbase supply wells located downgradient of Zone 5.

4.3.4 ZONE 6--HIGHWAY 98 FIRE TRAINING AREA

The Highway 98 fire training area (Zone 6) is located between the power check pads (Facility 84) and Highway 98 (Fig. 4.3-6). Zone 6 was used as a fire training area from 1952 to 1968. This site was one of the main repositories for waste POL from industrial operations at Tyndall AFB. Two 20,000-gal waste POL storage tanks utilized at the site were relocated in 1968. Standard procedures for the fire training exercises were to pour waste POL onto an old aircraft or simulated aircraft located in a bermed area, and then set the aircraft on fire. Most of the waste POL was consumed in the fire; however, some percolation into the surficial aquifer may have taken place. During the Phase I records search, it was reported by one interviewee that waste POL was sometimes taken to fire training areas by flight-line personnel and dumped into the bermed training area instead of the waste POL storage tank.

Previous analytical results from the Phase II, Stage 1 study for this site indicate a wide range of contaminants in the surficial aquifer at this site including lead, phenolics, and volatile organics.

One upgradient monitoring well (T6-5) and one downgradient monitoring well (T6-6) were installed at Zone 6 to supplement three existing monitor wells. The sediments underlying Zone 6 generally consisted of unconsolidated clean sand through the depths penetrated (see Fig. 4.3-7). Lithologic descriptions from borings performed during both the Phase II, Stage 1 study (Thiess et al., 1984) and this study indicate the site is underlain by fine- to medium-grained, poorly graded, quartz sand. Traces of organic material and heavy minerals were noted at some wells, and silt content ranged from 0 to 10 percent across the site. The sediments ranged from white to light brown to dark brown across the site.

Water-table elevations based on measurements made at all new and existing monitor wells ranged from 19.9 to 20.9 ft above sea level; the elevation of the potentiometric surface of the shallow aquifer varied by only

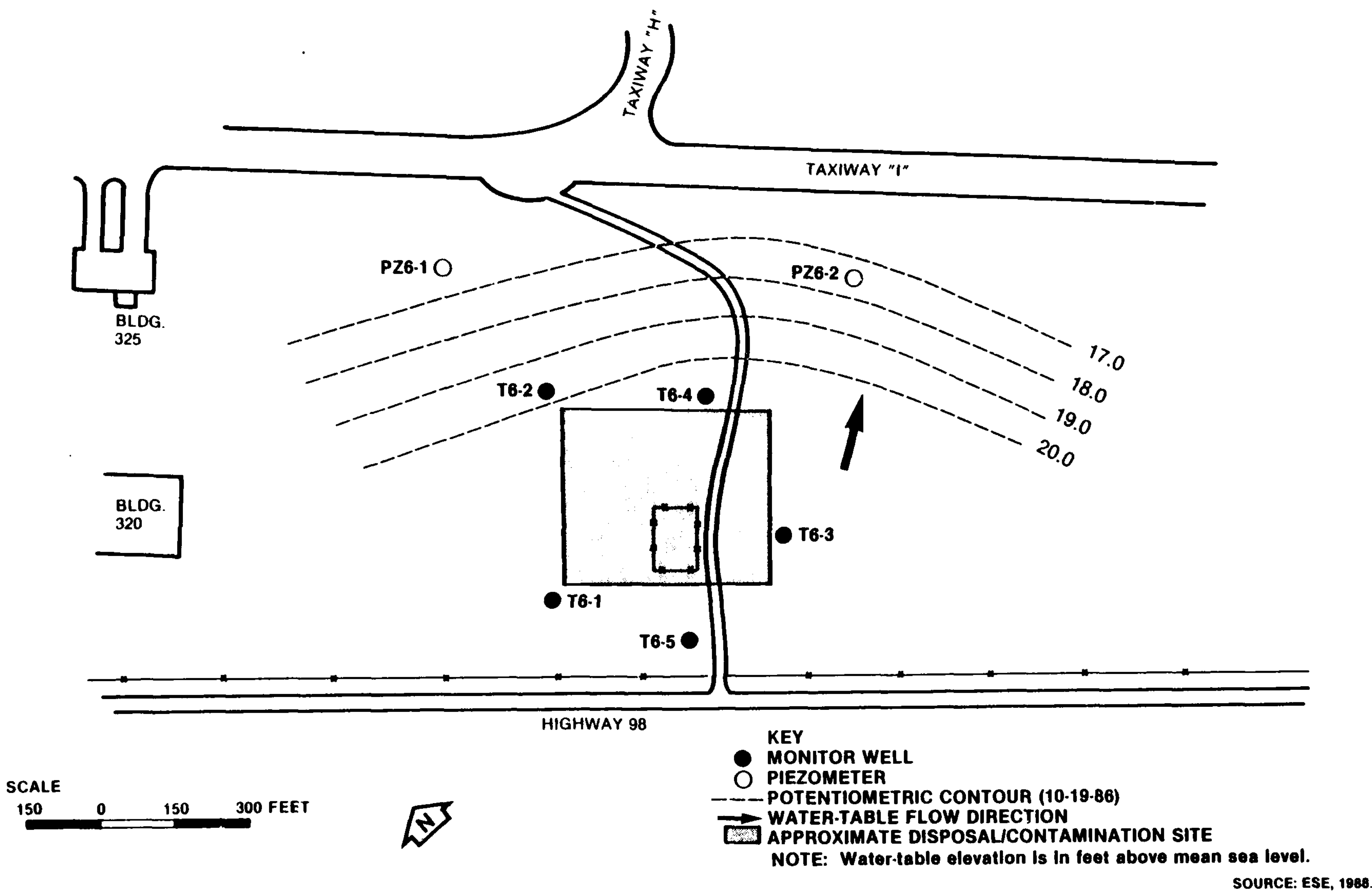

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Figure 4.3-6
SITE MAP FOR ZONE 6 — HIGHWAY 98 FIRE TRAINING AREA

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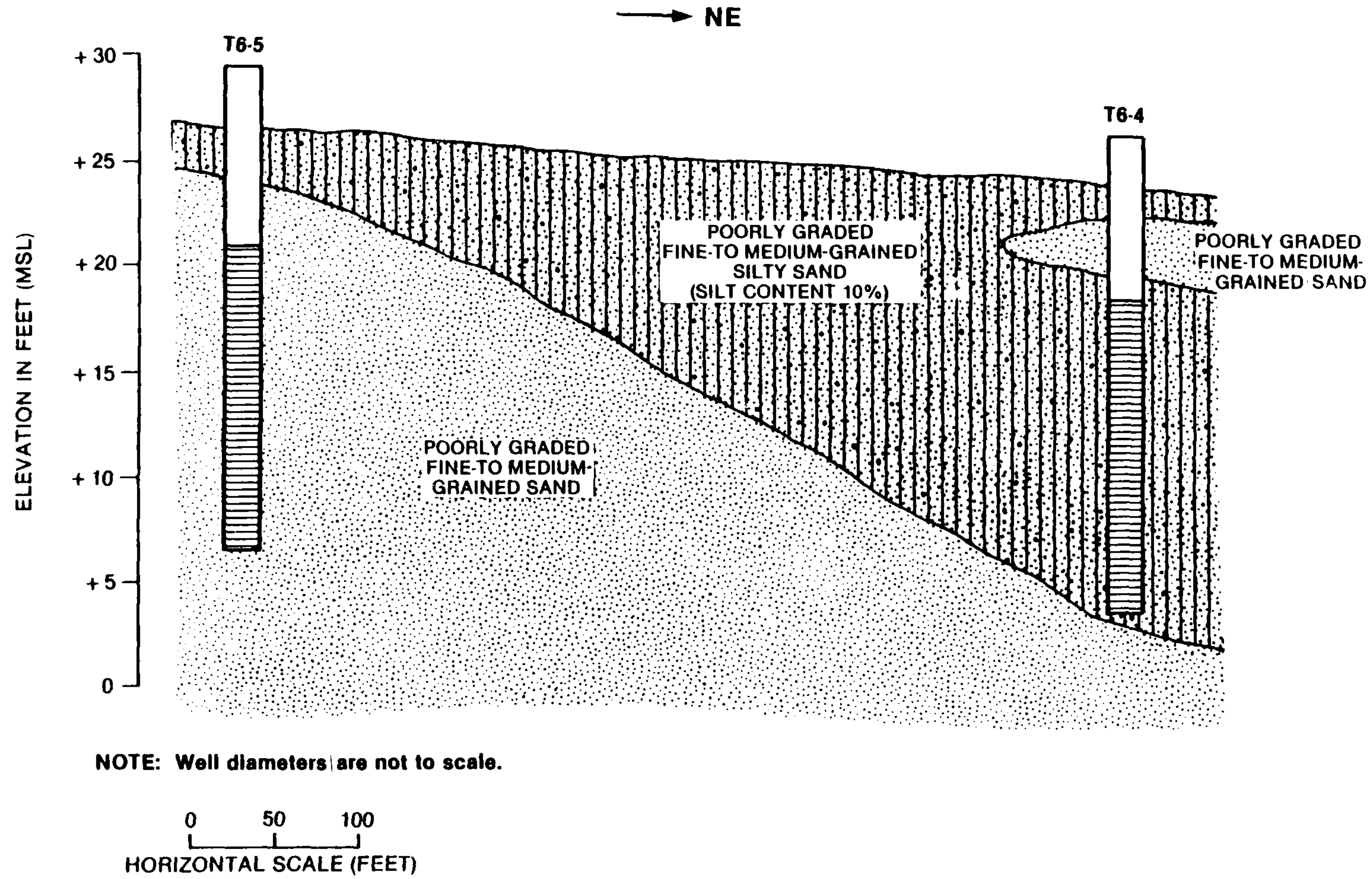

SOURCE: ESE, 1988.

Figure 4.3-7
ZONE 6 — SHALLOW GEOLOGIC CROSS SECTION

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1.0 ft across the site, based on measurements made at all new and existing monitor wells. This zone is near the crest of the ridge along which U.S. Highway 98 runs, with ground surface elevations descending southwestward and northeastward away from the ridge. Based on water-level data obtained from both piezometers and monitoring wells located at the site, ground water flow appears to be in a northeast direction toward Taxiway I and away from U.S. Highway 98.

A sample of the drill cuttings was collected and sent to ESE's laboratory in Gainesville, Florida, and tested for EP toxicity. The results of this analysis (Appendix S) showed the cutting not to exceed the threshold for a hazardous waste. If a solid waste exhibits the characteristic of EP toxicity, the solid waste is then classified as a hazardous waste and must be disposed in a proper manner. The concentration of eight metals and five pesticides is evaluated as part of the EP toxicity test.

Detectable concentrations of various analytes found in ground water samples at Zone 6 are presented in Table 4.3-4. Ground water samples from five monitoring wells were analyzed for pH, specific conductance, purgeable organics, acid extractable organics, petroleum hydrocarbons, and lead.

The pH and specific conductance values measured at Zone 6 were within levels typical for the Tyndall AFB area.

Six volatile organic compounds were detected and confirmed in ground water samples from this zone. Five additional compounds [chlorobenzene, chloroform, dichlorobenzene (total), trichlorofluoromethane, and ethylbenzene] were detected, but could not be verified by second-column analysis.

Table 4.3-4. Analytical Results for Ground Water Samples with Detectable Levels of Contaminants from Zone 6

Parameter	Ground Water T6-1	T6-2	T6-3	T6-4	T6-4+	T6-5	Detection Limits	NPDWR MCLs
ph Field (Standard Units)	6.00	4.80	5.90	6.20		5.60	0.050	
Specific Conductance (umhos/cm)	92	61	302	379		142	0.050	
Chlorobenzene (ug/L)	ND	ND	0.24*	ND	NA	ND	0.050	
Chloroform (ug/L)	ND	<1.0	<1.0	0.11*	NA	ND	0.050	100 (100)
Chloromethane (ug/L)	ND	ND	0.11*	ND	NA	ND	0.050	
Dichlorobenzene (Total) (ug/L)	ND	ND	0.41*	ND	NA	ND	0.050	750**
1,2-Dichloroethane (ug/L)	ND	0.32	0.11*	0.07	NA	ND	0.050	5 (3)
Trans-1,2-Dichloroethene (ug/L)	ND	0.04++	7.0	1.1*	NA	0.13*	0.050	
Trichloroethene (ug/L)	ND	0.060	ND	ND	NA	ND	0.050	5 (3)
Trichlorofluoromethane (ug/L)	ND	ND	0.060*	ND	NA	ND	0.050	
Vinyl Chloride (ug/L)	ND	0.16*	0.14***	0.24	NA	0.10*	0.050	1 (1)
Benzene (ug/L)	ND	94	260	6.0	NA	0.56	0.50	5 (1)
Ethylbenzene (ug/L)	ND	2.5*	1.7*	ND	NA	ND	0.50	
Toluene (ug/L)	ND	ND	5.0	1.0*	NA	1.0	0.50	
Petroleum Hydrocarbons (mg/L)	0.13	ND	4.9	ND	0.12	0.80	0.10	
Lead Total (mg/L)	ND	0.017	0.023	0.0043	0.0043	0.0032	0.0031	0.050 (0.050)

Notes: NA = not analyzed.
ND = not detected.
All other parameters analyzed at Zone 6 were below analytical detection limits.
Complete analytical results for Zone 6 are presented in Appendix R.
Values in parentheses are State of Florida MCLs.

*Single-column quantification, unable to confirm by second column due to interference.
**Proposed EPA MCL for 1,4-dichlorobenzene.
++Primary column indicates 3.8 ug/L of total 1,2-dichloroethene; however, the secondary column shows the peak to probably be cis 1,2-dichloroethene, which is a nontarget compound.
***Vinyl chloride co-elutes with dichlorodifluoromethene on the primary column. The second column indicates the major peak to be probably dichlorodifluoromethene and a second peak to be either vinyl chloride or chloromethane or both, making confirmation of either impossible. There is a response on the PID on the primary column, indicating a probable presence of vinyl chloride, but, as stated above, the hit cannot be confirmed.

Source: ESE, 1988.

Detectable levels of 1,2-dichloroethane were found at downgradient Wells T6-2 and T6-4 at concentrations of 0.32 and 0.07 µg/L, respectively. Both concentrations were below the NPDWR MCL of 5 µg/L and the state MCL of 3 µg/L. Trans-1,2-dichloroethene, a degradation product of trichloroethene, was present in the ground water sample from Well T6-3 at a concentration of 7.0 µg/L. This concentration was below the EPA Lifetime Health Advisory Level of 70 µg/L. This compound was also detected during the Phase II, Stage 1 investigation at Wells T6-1 and T6-3 at concentrations of 6 and 10 µg/L, respectively (Thiess et al., 1984). Trichloroethene was confirmed in Well T6-2 at a concentration of 0.06 µg/L, below the state MCL of 3 µg/L and the NPDWR MCL of 5 µg/L. Vinyl chloride was detected in Well T6-4 at a concentration of 0.24 µg/L, which is below both the state and NPDWR MCL for vinyl chloride of 1 µg/L. Vinyl chloride was not detected during the Phase II, Stage 1 investigation (Thiess et al., 1984).

Evidence of petroleum contamination was found at all five monitoring wells at Zone 6. Benzene was present in Wells T6-2 through T6-5. The highest concentration of benzene was found in Well T6-3 (260 µg/L), followed by 94 µg/L in Well T6-2, 6.0 µg/L in Well T6-4, and 0.63 µg/L in Well T6-5. Benzene concentrations in all three wells exceeded the MPDWR MCL of 5 µg/L, as well as the state MCL of 1 µg/L. During the Phase II, Stage 1 studies, benzene was detected in Wells T6-1 and T6-3 at concentrations of 12 and 94 µg/L, respectively (Thiess et al., 1984).

Toluene is used as a solvent and also occurs naturally as a component of petroleum products, and was present at low levels in Wells T6-3 and T6-5 at concentrations of 5.0 and 1.0 µg/L, respectively. Concentrations of toluene found at Zone 6 were all well below the EPA Lifetime Health Advisory Level of 2,000 µg/L.

Detectable levels of total petroleum hydrocarbons were present in Wells T6-1, T6-3, and T6-5 at concentrations of 0.13, 4.9, and 0.80 mg/L, respectively. Well T6-3 showed the greatest degree of petroleum contamination with the highest concentrations of total petroleum hydrocarbons, toluene, and benzene.

Lead was detected in Wells T6-2, T6-3, T6-4, and T6-5 at concentrations of 0.017, 0.023, 0.0043, and 0.0032 mg/L, respectively. Lead concentrations in all ground water samples from Zone 6 were below the state and NPDWR MCL of 0.050 mg/L and were not a sign of significant lead contamination.

All analytical results for acid extractable organics (phenolic compounds) for Zone 6 were below analytical detection limits.

Significant Findings

Six volatile organic compounds were detected and confirmed at Zone 6 including chlorinated solvents and petroleum-related contaminants (e.g., benzene). All volatile organic compounds were below applicable state and EPA criteria with the exception of benzene, which exceeded the NPDWR and state MCLs of 5 and 1 µg/L, respectively.

Analytical results for Zone 6 indicate that Well T6-1 is free from detectable levels of volatile organic compounds and lead. However, trace levels of total petroleum hydrocarbons were detected at a concentration of 0.12 mg/L. All remaining monitor wells (T6-2 through T6-5) showed detectable levels of both volatile organic compounds and low levels of lead. All lead concentrations detected in ground water samples from this Zone were below NPDWR and state MCLs of 0.05 mg/L and were not indicative of significant contamination. Well T6-3 showed the overall highest levels of contamination of petroleum hydrocarbons at Zone 6. Well T6-3 was also found to be the most highly contaminated well at Zone 6 during the Phase II, Stage 1 studies (Thiess et al., 1984).

Phenolic compounds were found to be present at all three monitor wells during the Phase II, Stage 1 studies, with concentrations of total phenolic compounds ranging from 32 to 54 µg/L. However, results of the current study showed all phenolic compounds included in the acid extractable group to be below analytical detection limits at all Zone 6 monitor wells.

With the exception of benzene, all contaminants detected at Zone 6 were present at concentrations below applicable state and NPDWR MCLs. Since the surficial aquifer is not used as a potable water source, an imminent human health hazard resulting from consumption of contaminated ground water does not appear to exist at Zone 6. The areal and vertical extent of contaminants observed in the ground water cannot be fully defined, based on the existing monitor well network. Both upgradient and downgradient monitor wells were found to contain detectable levels of contaminants. The contaminants detected at Zone 6, i.e., chlorinated solvents and petroleum-related organic compounds such as benzene, are typical of contaminants encountered at fire training areas where waste POLs are stored and used in fire training activities.

4.3.5 ZONE 7--SOUTHEAST RUNWAY EXTENSION BURIAL SITE

The Southeast Runway Extension Burial Site (Zone 7) is located at the southeast end of the runway near the Alert Facility (Fig. 4.3-8). This site was reported to have been used intermittently from 1945 to 1965 for disposal of used containers, drums, old batteries, and old parts. No information is available to indicate the quantity of material disposed in this area or if the drums and containers were empty. Apparently, the material was placed in narrow excavated trenches. Information on past industrial operations indicates that the industrial shops, which generate the majority of hazardous wastes such as chlorinated solvents, were not in operation during this time.

Analytical results from the Phase II, Stage 1 survey indicate the presence of chlorinated solvents and total phenolics at this zone.

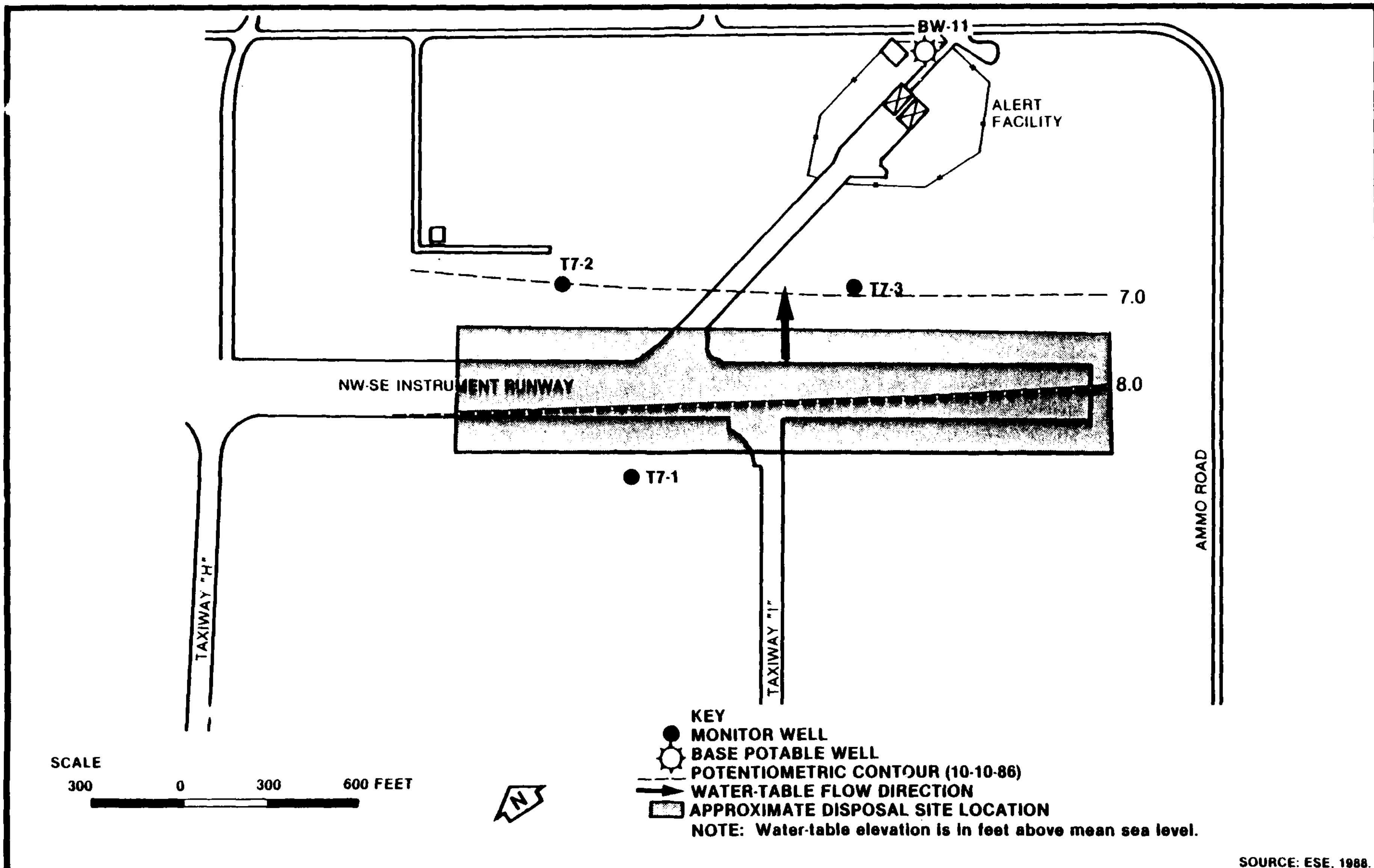

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Figure 4.3-8
SITE MAP FOR ZONE 7 — SOUTHEAST RUNWAY EXTENSION LANDFILL

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No monitor wells were installed at Zone 7 during the Phase II, Stage 2 investigation since the three existing monitoring wells were thought to provide adequate control for evaluation of current hydraulic and ground water conditions. To provide additional information on ground water quality at Zone 7, a water sample was obtained from Base Well 11, located at the Alert facility.

Lithologic descriptions of sediments underlying Zone 7 were derived from the Phase II, Stage 1 boring descriptions (Thiess et al., 1984). Sediments were described every 5 ft, with no description provided for the intermittent intervals; therefore, contacts between units cannot be defined at exact depths. The sediments underlying Zone 7 generally consisted of clean sand. At Well T7-1, very fine- to fine-grained, poorly graded, quartz sands were encountered from the ground surface to a depth of 16.5 ft (deepest described interval). These sands contained trace amounts of silt, clay, and organic material. Similar sands were reported at Wells T7-2 and T7-3 to a depth of 11.5 ft. At Well T7-2, sediments at a depth of 15.0 to 16.5 ft were described as very-fine-grained sand with 30-percent silt and clay. Sediments at the same depth at Well T7-3 were described as pure clay.

Water-table levels in the monitor wells ranged from 7.0 to 8.8 ft above sea level, with the elevation of the potentiometric surface of the shallow aquifer mapped in Fig. 4.3-8. Direction of ground water flow was toward the northeast, eventually discharging into East Bay. Recharge to Wells T7-1 and T7-3 was sufficient to allow continuous pumping during purging, whereas Well T7-2 was pumped discontinuously. Lithologic descriptions from these boreholes obtained from the Phase II, Stage 1 report did not indicate any distinct reason for lower productivity at Well T7-2. Individual well production ranged from 0.4 to 3.3 gpm.

Water-table levels ranged from 1.4 to 2.6 ft below ground surface. Direction of the surficial aquifer was toward the northeast, eventually discharging to East Bay.

Detectable concentrations of various analytes found in ground water samples at Zone 7 are presented in Table 4.3-5. Ground water samples from four monitoring wells were analyzed for pH, specific conductivity, purgeable organics, base/neutral and acid extractable organics, pesticides, herbicides, polychlorinated biphenyls (PCBs), and priority pollutant metals.

The pH values ranged from 4.8 at Well T7-3 to 7.9 at Base Well 11. Specific conductance ranged from 66 umhos/cm at Well T7-1 to 1,310 umhos/cm at Base Well 11. Both pH and specific conductance values were within the range for the Tyndall AFB area. Specific conductance reported for Base Well 11 (1,310 umhos/cm) is significantly above the other three monitor wells at Zone 7. Base Well 11 currently is screened at a depth of 110 to 115 ft, as compared to a screened interval of 5 to 15 ft for the other monitor wells. The elevated specific conductance in this well is likely because of saltwater intrusion, which has been reported for this well (Thiess et al., 1986).

One volatile organic compound (1,1,1-trichloroethane) was detected and confirmed in ground water from Base Well 11 at a concentration of 0.06 µg/L, which is below the state and proposed NPDWR MCL of 200 µg/L, and near the analytical detection level of 0.05 ug/L. Chlorobenzene and chloroform were also detected, but could not be confirmed by second-column analysis, as required for all GC analyses (see Sec. 4.2). Results from the Phase II, Stage 1 report (Thiess et al., 1984) showed 1,1,1-trichloroethane to be present in Base Well 11, at a concentration of 8 µg/L. Methylene chloride was also found in Base Well 11 during the Phase II, Stage 1 study at a concentration of 9 µg/L, but was not detected during the Phase II, Stage 2 investigation.

Bis(2-ethylhexyl)phthalate, commonly used as a plasticizing additive, was detected in Well T7-3 at a concentration of 52 µg/L and in Base Well 11 at a concentration of 6.6 µg/L. Both concentrations are below the EPA

Table 4.3-5. Analytical Results for Ground Water Samples with Detectable Levels of Contaminants from Zone 7

Parameter	Ground Water					Detection Limits	NPDWR MCLs
	T7-1	T7-1†	T7-2	T7-3	BW7-11		
pH Field (Standard Units)	5.7		5.5	4.8	7.9		
Specific Conductance (umhos/cm)	66		69	98	1,310		
Chlorobenzene (ug/L)	ND	ND	ND	ND	3.4*	0.050	
Chloroform (ug/L)	ND	0.06*	ND	ND	0.080*	0.050	100(100)
1,1,1-Trichloroethane (ug/L)	ND	ND	ND	ND	0.060	0.050	200(200)
Bis(2-ethylhexyl)phthalate (ug/L)	ND	NA	ND	52	6.6	1.0	
Di-n-octylphthalate (ug/L)	ND	NA	ND	1.4	ND	1.1	
Arsenic, Total (mg/L)	ND	NA	0.065	0.069	ND	0.060	0.050(0.050)
Beryllium, Total (mg/L)	0.0087	NA	0.011	0.0054	ND	0.0010	
Chromium, Total (mg/L)	ND	NA	0.015	0.017	ND	0.0060	0.050(0.050)
Nickel, Total (mg/L)	ND	NA	0.016	ND	ND	0.015	
Thallium, Total (mg/L)	ND	NA	ND	ND	0.062	0.037	
Zinc (mg/L)	ND	NA	ND	0.0051	0.0034	0.0030	(5)

Notes: ND = not detected.
NA = not analyzed.
All other parameters analyzed at Zone 7 were below analytical detection limits.
Complete analytical results for Zone 7 are presented in Appendix R.
Values in parentheses are State of Florida MCLs.

*Single-column quantification, unable to confirm by second column due to interference.
†Field duplicate.

Source: ESE, 1988.

ambient water quality criterion for the protection of human health for toxicity of 15,000 µg/L. Di-n-octylphthalate was present in Well T7-3 at a concentration of 1.4 µg/L. There are currently no state or Federal criteria for di-n-octylphthalate. The method blanks run with the samples were free of detectable phthalates.

Phenolic compounds were not detected in ground water samples from Zone 7.

Six priority pollutant metals were detected at Zone 7. Arsenic was present in Wells T7-2 and T7-3 at concentrations of 0.065 and 0.069 mg/L, respectively. Both concentrations exceeded the state and NPDWR MCLs for arsenic of 0.05 mg/L. Beryllium was detected in Wells T7-1, T7-2, and T7-3 at concentrations ranging from 0.0054 mg/L at Well T7-3 to 0.011 mg/L at Well T7-2. Beryllium concentrations in all three wells exceeded the EPA ambient water quality criterion for the protection of human health for carcinogenicity of 3.7×10^{-6} mg/L. Currently, there are no state or NPDWR MCLs for beryllium. Nickel was present in Well T7-2 at a concentration of 0.06 mg/L, below the EPA Health Advisory Level of 0.15 mg/L. Thallium was present in Base Well 11 at a concentration of 0.062 mg/L, exceeding the EPA ambient water quality for the protection of human health toxicity of 0.013 mg/L. Zinc was present in Well T7-3 and Base Well 11 at levels of 0.0051 to 0.034 mg/L, respectively. All zinc concentrations were below the state MCL of 5 mg/L, and were not representative of significant contamination.

Pesticides, herbicides, and PCBs were not detected in any ground water samples from Zone 7.

Significant Findings

Ground water data for Zone 7 indicate the presence of 1,1,1-trichloroethane (0.060 µg/L), phthalates, and priority pollutant metals in the surficial aquifer. Pesticides and PCBs were not detected at this site. The upgradient Well T7-1 had the lowest levels of contamination with all analytical results below detection limits with the exception of trace amounts of beryllium. Base Well 11 contained low concentrations of

1,1,1-trichloroethane (0.060 µg/L), and bis(2-ethylhexyl)phthalate (6.6 µg/L), both of which were below applicable water quality criteria. The concentration of 1,1,1-Trichloroethane detected in Base Well 11 was near the analytical detection limit of 0.050 µg/L, and does not indicate significant contamination at this site.

Arsenic was detected in Wells T7-2 and T7-3 at levels slightly exceeding the NPDWR and state MCL. Beryllium was also present in all three monitor wells at levels exceeding the EPA ambient water quality criteria for the protection of human health.

Base Well 11 is located at the Alert Facility, which is adjacent to Zone 7. This well is used as a nonpotable water source for flushing toilets at the Alert Facility. Bottled water is used at the Alert Facility for drinking purposes due to a high dissolved solids content and poor taste quality of the well water. Base Well 11 is screened at the 100- to 115-ft level, within the surficial aquifer. Thallium and zinc were detected in Base Well 11, with the concentration of thallium slightly exceeding the EPA ambient water quality criteria for the protection of human health for carcinogenicity. All other contaminants detected in Base Well 11 were present at concentrations below applicable state and Federal criteria.

The surficial aquifer is used as a nonpotable water source for the Alert Facility. Because thallium concentrations in Base Well 11 slightly exceed the EPA ambient water quality criteria for the protection of human health for carcinogenicity, the possibility for a human health hazard does appear to exist at Zone 7.

Base supply Well 4A is located approximately 3,600 ft east-northeast of Zone 7 in Bldg. 7001. This supply well is screened in the Floridan Aquifer at a depth of 280 to 435 ft. The direction of flow in the

Floridan Aquifer is toward the west, based on the potentiometric map for the Floridan Aquifer presented in Fig. 2.3-4. Therefore, Base Well 4A is upgradient of Zone 7 and should not be affected by contaminants at this zone.

Based on the results from the limited number of monitor wells sampled at this site, the areal and vertical extent of contamination at this site cannot be adequately assessed at this time.

4.3.6 ZONE 8--"6000" AREA LANDFILL

Zone 8, referred to as the "6000" Area Landfill, is located south of the pavements and grounds area of the base (Fig. 4.3-9). During the Phase I Records Search, several interviewees indicated that old parts, batteries, and empty containers were dumped intermittently in this area from 1945 to 1965. Visual inspection of the site during the Phase I Records Search revealed a cleared area of approximately 3 acres covered with vegetation, indicative of former disturbed soil conditions which may have resulted from a landfill operation. Aerial photographs obtained from the Base Civil Engineering Squadron during the Phase II, Stage 2 field effort indicate the landfill operation may have been somewhat larger.

During the Phase II, Stage 1 investigations, Zone 8 was found to have elevated levels of DOC and TOX.

A detailed geophysical survey incorporating magnetometer and EM techniques was conducted at the "6000" Area Landfill to delineate the lateral extent of the site and to determine whether any leachate plumes could be identified at the disposal area.

A discussion of geophysical techniques used in this study is presented in Appendix G. The results of the geophysical survey revealed the presence of metallic objects buried in the disposal area. The highest concentration of buried metallic objects was located in the northeast section of the landfill area. Slightly elevated conductivity readings were also observed along the northwest section of Zone 8, downgradient from the landfill area, and could represent a contaminant plume. However, this downgradient area was adjacent to a hardwood swamp, which is underlain by fine-grained silts and clays.

Conductivity measurements obtained by the geophysical survey are a function of the conductivity of both the pore fluid and the sediment type underlying the site, with clays providing elevated readings relative to

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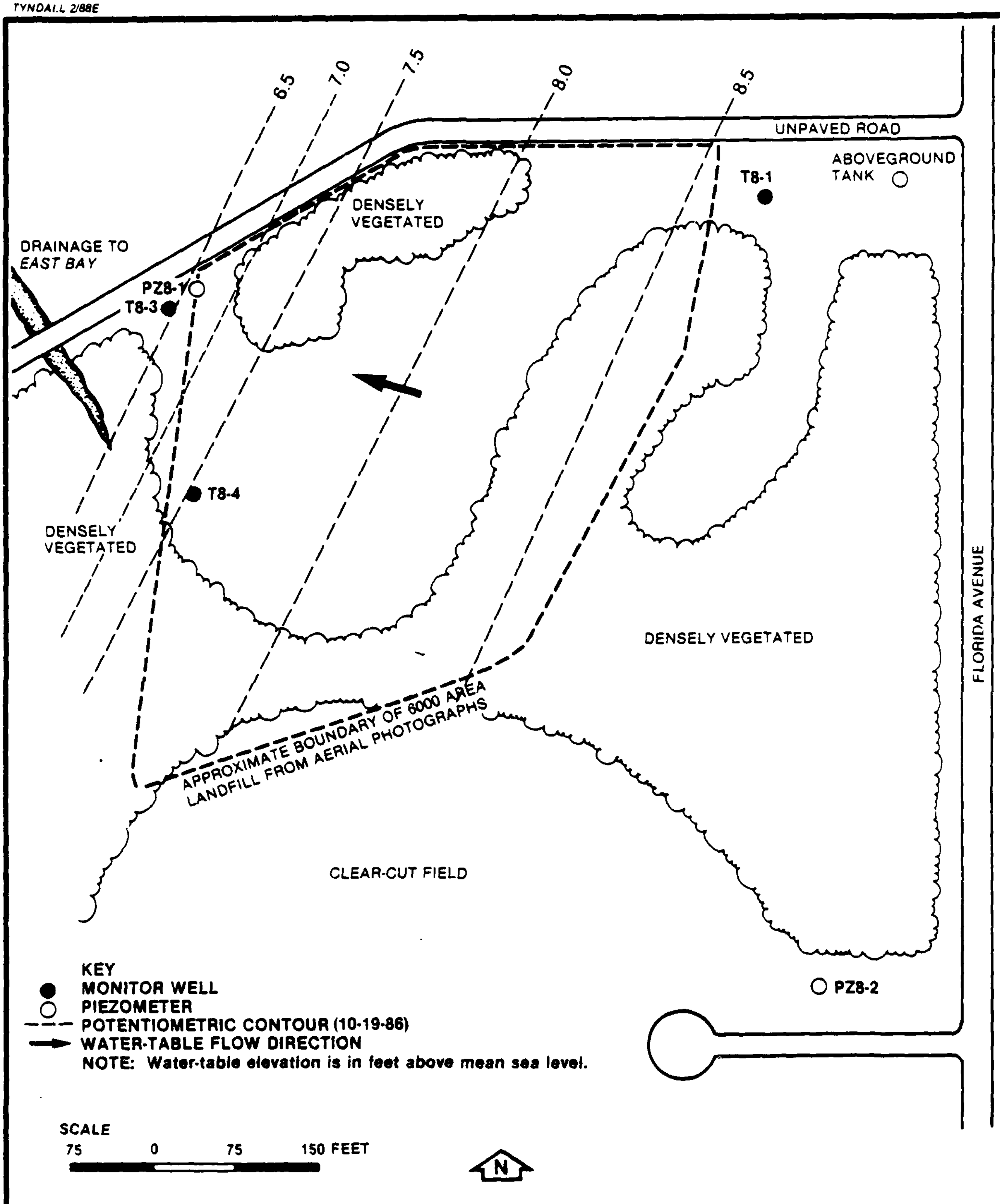

SOURCE: ESE, 1988.

Figure 4.3-9
SITE MAP FOR ZONE 8 — "6000" AREA LANDFILL

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clean sands. Since much of the landfill is underlain by sand where low subsurface conductivities were recorded, the somewhat elevated downgradient responses obtained by the EM conductivity meter were possibly a function of the presence of clays. Therefore, results of the geophysical surveys do not conclusively indicate the presence of a contaminant plume in the pore fluids.

Exceptionally low conductivity values were obtained across much of the upgradient portion of the landfill. Discussions with representatives of Geonics Limited, the manufacturer of the EM meter used to conduct the survey at Tyndall AFB, indicate these low measurements are not highly unusual and were probably a function of clean sands with little or no silt or clay content. Often when soils have been disturbed (such as landfilling) and are not in their natural setting, they are not as densely packed, which would contribute to lower conductivity values. These low-conductivity measurements are a strong indication that no conductive contaminant plume exists in the upgradient portion of the landfill. However, this does not eliminate the possible presence of a nonconductive organic contaminant plume.

Two downgradient monitoring wells (T8-3 and T8-4) were installed at Zone 8 (Fig. 4.3-9). A total of three monitoring wells was sampled at Zone 8. The sediments underlying Zone 8 generally consisted of unconsolidated clean sands and silty sands through the depths penetrated. No geologic cross section was prepared for this zone due to the high level of consistency in the sediments encountered. The upper 9 to 12 ft of sediments was comprised of very-fine to medium-grained, poorly graded, quartz sands with trace occurrences of silt, clay, heavy minerals, and organic and calcareous materials. Up to 10 percent silt was reported from this interval at Well T8-3. Sediments underlying this unit to the base of the boreholes were silty sands, with silt content ranging from 10 to 25 percent of the total composition.

Water-table levels ranged from 6.4 to 8.7 ft above sea level, with the elevation of the potentiometric surface of the shallow aquifer mapped in Fig. 4.3-9. Ground water flow direction is to the northwest toward a hardwood swamp area, which eventually discharges into East Bay. Recharge to Wells T8-3 and T8-4 was sufficient to allow continuous pumping during development and purging, with production approximately 2.4 gpm at each location. Well yield at existing Well T8-1 during purging was low, with long recharge intervals. The Phase II, Stage 1 report indicated the lower portion of this well to be screened is a silty sand containing 25-percent silt, which explains the low yield and long recharge intervals.

Detectable concentrations of various analytes found in ground water samples at Zone 8 are presented in Table 4.3-6. Ground water samples were collected from three monitoring wells and analyzed for pH, specific conductance, purgeable organics, base/neutral and acid extractable organics, pesticides, PCBs, and priority pollutant metals.

The pH values obtained at Zone 8 ranged from 5.8 to 6.3. Specific conductance values ranged from 185 umhos/cm at Well T8-4 to 720 umhos/cm at Well T8-1.

Ground water samples from all three monitor wells at Zone 8 were found to contain volatile organic compounds, phthalates, and priority pollutant metals. Trace levels of chloroform and chloromethane were both detected and confirmed in Well T8-4 at concentrations of 0.090 and 0.10 µg/L, respectively. The concentration of Chloroform was below the state and NPDWR MCL for total THMs of 100 µg/L, while chloromethane was below the EPA ambient water quality criterion for the protection of human health for carcinogenicity of 0.19 µg/L. Well T8-1 contained trichlorofluoromethane (freon) at a concentration of 0.12 µg/L. This concentration was below the EPA lifetime reference dose of 10,000 µg/L. The compound 1,2-dichloropropane was detected and confirmed in Well T8-1

Table 4.3-6. Analytical Results for Ground Water Samples with Detectable Levels of Contaminants from Zone 8

Parameter	Ground Water				Detection Limits	NPDWR MCL
	T8-1	T8-3	T8-3+	T8-4		
pH field (standard units)	6.3	5.8		5.8		
Specific conductivity (umhos/cm)	720	353		185		
Chloroform (ug/L)	ND	ND	ND	0.090	0.050	100 (100)
Chloromethane (ug/L)	ND	ND	ND	0.10	0.050	
T-1,2-Dichloroethene (ug/L)	0.17*	ND	ND	ND	0.050	
1,2-Dichloropropane (ug/L)	.065	ND	ND	ND	0.050	
Trichlorofluoromethane (ug/L)	0.12	ND	ND	ND	0.050	
Vinyl chloride (ug/L)	0.12*	ND	ND	ND	0.050	1 (1)
Bis(2-ethylhexyl)phthalate (ug/L)	3.6	11	9.5	4.5	1.1	
Di-n-octylphthalate (ug/L)	ND	ND	ND	2.2	1.1	
Arsenic Total (mg/L)	ND	ND	NA	0.061	0.060	0.050 (0.050)
Chromium Total (mg/L)	ND	ND	NA	0.014	0.0060	0.050 (0.050)
Copper Total (mg/L)	0.011	ND	NA	ND	0.0060	(1)
Silver Total (mg/L)	0.0075	0.0059	NA	0.0063	0.0060	0.050 (0.050)
Zinc Total (mg/L)	0.040	0.011	NA	0.038	0.0030	(5)

Notes: ND = not detected.
NA = not analyzed.
All other parameters analyzed at Zone 8 were below analytical detection limits.
Complete analytical results for Zone 8 are presented in Appendix R.
Values in parentheses are State of Florida MCLs.

*Single-column quantification, unable to confirm by second column due to interference.
+Field duplicate.

Source: ESE, 1988.

at a concentration of 0.065 µg/L, which is below the proposed RMCL of 6 µg/L, and only slightly above the analytical detection limit for this compound of 0.050 µg/L.

Bis(2-ethylhexyl)-phthalate was detected in all three monitoring wells at concentrations below the ambient water quality criterion for the protection of human health for toxicity of 15,000 µg/L.

Di-n-octylphthalate was present in Well T8-4 at a concentration of 2.2 µg/L. There are currently no state or Federal water quality criteria for this compound; however, phthalates as a group have a relatively low level of toxicity.

Phenolic compounds were not detected in ground water samples from this site.

A total of five priority pollutant metals were identified in the three monitoring wells at Zone 8. Arsenic was present in Well T8-4 at a concentration of 0.061 mg/L, which was in excess of the 0.05-mg/L state and NPDWR MCL. Arsenic was not present in Well T8-1 or T8-2. The concentration of arsenic detected in Well T8-4 (0.061 µg/L) was only slightly above the analytical detection limit of 0.060 µg/L. Chromium was present in Well T8-4 at a concentration of 0.014 mg/L, below the state and NPDWR MCLs of 0.05 mg/L. Copper was detected in monitor Well T8-1 at a concentration of 0.011 mg/L, which was well below the state MCL of 1.0 mg/L. All three wells at Zone 8 were found to contain trace levels of silver, with all concentrations below the state and NPDWR MCLs of 0.05 mg/L. Trace amounts of zinc were also detected in all three wells. All zinc concentrations were below the state MCL of 5 mg/L.

Significant Findings

Monitor wells at Zone 8 were found to contain detectable concentrations of volatile organic compounds, phthalates, and priority

pollutant metals. However, all compounds and metals detected at this site were below applicable state and EPA drinking water standards with the exception of arsenic. All monitor wells at Zone 8 were free from detectable levels of phenolic compounds, pesticides, and PCBs.

Results of the chemical analysis of ground water samples from this site do not indicate high levels of contamination or contaminant migration from Zone 8. Although six organic compounds and five priority pollutant metals were detected in the surficial aquifer at Zone 8, only arsenic slightly exceeded the state and NPDWR MCL. Analytical results for the ground water sample collected from Well T8-1 indicate that this well is not located upgradient of all contaminants at Zone 8. However, all contaminants detected at this well were present at low concentrations below their respective MCLs. The areal and vertical extent of contaminants observed in ground water at this zone cannot be fully identified based on the existing network of monitoring wells.

Two base supply wells are located within 1,000 ft of Zone 8. Base Well 5A is located at a distance of 250 ft from Zone 8 and is screened in the Floridan Aquifer at a depth of 435 to 463 ft. Base Well 10 is located 750 ft from Zone 8 and also is screened in the Floridan Aquifer at a depth of 316 to 600 ft. Both base wells are located upgradient of Zone 8 and are thus not subject to contamination from this site.

Since the surficial aquifer is not used as a potable water source, an imminent health hazard does not appear to exist at Zone 8 from the consumption of ground water.

4.3.7 ZONE 9--POL AREA B

Zone 9, referred to as POL Area B, is located in the flight line area of the base near the Area "500" tank farm (Fig. 4.3-10). This POL area is a relatively small storage area which may have small amounts of sludge buried onsite. Fuels stored at this site include: JP4, Diesel Fuel

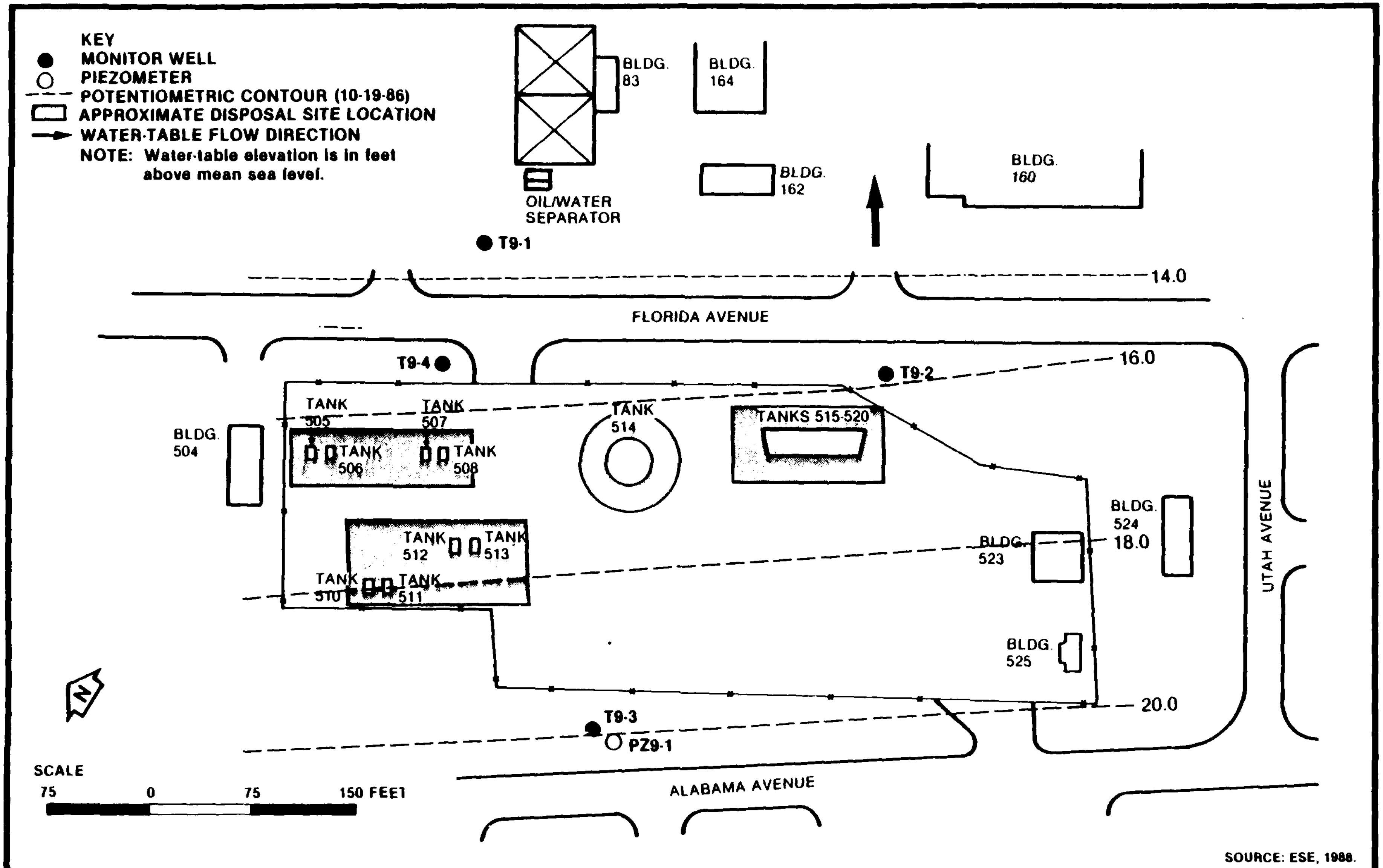

Figure 4.3-10
SITE MAP FOR ZONE 9 — POL AREA B

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No. 2, and motor gasoline. Lead was not detected in monitoring wells during Phase II, Stage 1 investigations, although TOX and DOC indicators suggest possible organic contamination.

One upgradient monitor well (T9-3) and one downgradient monitor well (T9-4) were installed at Zone 9 to supplement the existing monitor well network. Onsite measurement of organic vapors indicated the potential presence of contaminants in the cuttings; therefore, all cuttings were containerized in drums for removal from the site. To determine the proper method of disposal, the cuttings from this site were analyzed for EP toxicity and found to be below the level to be classified as a hazardous waste (see Appendix S for data). The pre-existing well, T9-1, although adequately positioned to intercept downgradient flow from Zone 9, was not situated close enough to the site to eliminate other possible sources of water quality interference. An oil/water separator unit lies less than 100 ft away from T9-1 and could be a more pertinent contributor to ground water quality in the vicinity of T9-1 than the POL tanks, which lie about 200 ft away, across Florida Avenue.

The sediments underlying Zone 9 generally consisted of unconsolidated clean sands with minor occurrences of silty sands through the depths penetrated. A geologic cross section was not prepared for Zone 9 due to the high level of uniformity in the subsurface environment. All boreholes were dominantly composed of very fine- to fine-grained, poorly graded, quartz sand with trace occurrences of organic material. Silt and clay content ranged from 0 to roughly 10 percent of the total composition. One exception occurred at the interval between 15.0 to 16.5 ft at Well T9-2, where silt and clay constituted 20 percent of the total composition of the sample. The sediments were often dark brown to black in color.

Water-table levels measured in the monitor wells ranged from 13.6 to 20.0 ft above sea level, with the elevation of the potentiometric surface

of the shallow aquifer mapped in Fig. 4.3-10. Ground water flow direction is to the northeast. Recharge to Wells T9-1, T9-2 and T9-3 was sufficient to allow continuous pumping during development and purging, whereas Well T9-4 produced poorly and required discontinuous pumping.

Detectable concentrations of various analytes found in ground water samples from Zone 9 are presented in Table 4.3-7. Ground water samples from four monitor wells were analyzed for pH, specific conductance, purgeable organics, EDB, petroleum hydrocarbons, and lead.

The pH values measured at Zone 9 ranged from 4.60 at Well T9-1 to 5.80 at Well T9-3. Specific conductance values obtained at Zone 9 ranged from 83 μmhos/cm at Well T9-4 to 107 μmhos/cm at Well T9-3.

Detectable concentrations of volatile organic compounds were present in all wells at Zone 9, with the exception of the upgradient well (T9-3). The only analytes detected in T9-3 were total petroleum hydrocarbon at a concentration at 0.59 mg/L and lead at a concentration of 0.0086 mg/L. The lead concentration detected in Well T9-3 was very low, just above the analytical detection limit of 0.0031 mg/L, and is not considered to indicate significant contamination in this well. There are no state or Federal drinking water criteria for total petroleum hydrocarbons; however, the level detected at T9-3 was well below the state water quality criterion of 5.0 mg/L for Class II surface waters for oil and grease. Lead in this well was below the state and NPDWR MCL of 0.050 mg/L.

Chloroform was detected and confirmed in Well T9-2 at a concentration of 0.050 μg/L, which is at the analytical detection limit for this compound and below the NPDWR and state MCLs for total THMs of 100 μg/L. Well T9-1 was found to contain various chlorinated solvents, including 1,2-dichloroethane (0.60 μg/L), 1,2-dichloropropane (0.050 μg/L), and 1,1,1-trichloroethane (0.050 μg/L). All of these contaminants were

Table 4.3-7. Analytical Results for Ground Water Samples with Detectable Levels of Contaminants from Zone 9

Parameter	Ground Water				Detection Limits	NPDWR MCL
	T9-1	T9-2	T9-3	T9-4		
pH field (Standard Units)	4.60	4.90	5.80	5.10		
Specific Conductance (umhos/cm)	84.0	98.0	107	83.0		
Chloroform (ug/L)	ND	0.050	ND	ND	0.050	100 (100)
1,2-Dichloroethane (ug/L)	0.60	ND	ND	ND	0.050	5 (3)
T-1,2-Dichloroethene (ug/L)	0.25*	ND	ND	0.37*	0.050	
1,2-Dichloropropane (ug/L)	0.050	ND	ND	ND	0.050	
1,1,1-Trichloroethane (ug/L)	0.050	ND	ND	ND	0.050	200 (200)
Benzene (ug/L)	12+	ND	ND	270	0.50	5 (1)
Ethylbenzene (ug/L)	3.7+	ND	ND	140	0.50	
Toluene (ug/L)	3.2+	ND	ND	140	0.50	
Xylenes, Total (ug/L)	46+	9.3+	ND	1,500*	5.0	
Petroleum Hydrocarbons (mg/L)	ND	0.17	0.59	6.0	0.18	
Lead (mg/L)	0.026	ND	0.0086	0.033	0.0031	0.050 (0.050)

Notes: ND = not detected.
All other parameters analyzed at Zone 9 were below analytical detection limits.
Complete analytical results for Zone 9 are presented in Appendix R.
Values in parentheses are State of Florida MCLs.

*Single column quantification, unable to confirm by second column due to interference.
+Single column quantification, second-column confirmation was not conducted.

Source: ESE, 1988.

present at levels below their respective state and NPDWR MCLs and EPA Health Advisory Level for drinking water. Trans-1,2-dichloroethane was also detected in Well T9-1, but could not be confirmed by second column analysis. Trans-1,2-dichloroethane was also detected in Well T9-4, but could not be confirmed by second column confirmation. None of the chlorinated solvents present in Well T9-1 were detected in Well T9-4. Since Well T9-4 is upgradient of T9-1, there must be another source of chlorinated solvent contamination downgradient of Well T9-4 which is contributing to the contamination detected in Well T9-1 (see Fig. 4.3-10). Well T9-1 is located near an oil/water separator close to an aircraft maintenance building. It is possible that the solvents detected in Well T9-1 may be associated with the oil/water separator, along with activities at the aircraft maintenance building. However, this association is unconfirmed at this time.

Benzene was detected in Wells T9-4 and T9-1 at concentrations of 270 and 12 μg/L, respectively. Both concentrations are above the NPDWR MCL of 5 μg/L and state MCL of 1 μg/L. Second column analysis was not conducted for benzene for Well T9-1. Ethylbenzene was also detected in Wells T9-4 and T9-1 at concentrations of 140 and 3.7 μg/L, respectively. Both concentrations were well below the EPA Health Advisory level of 680 μg/L. Second column confirmation for ethylbenzene for Well T9-1 was not conducted. Toluene was detected in Wells T9-4 and T9-1 at levels of 140 and 3.2 μg/L, respectively. Both levels are below the EPA Health Advisory Level of 2,000 μg/L. Second column confirmation was not conducted for toluene at Well T9-1. Concentrations of total xylenes present in Wells T9-4, T9-1, and T9-2 were 1,500, 46, and 9.3 μg/L, respectively. Concentrations of total xylene in Wells T9-1 and T9-2 were below the EPA Health Advisory Level of 440 μg/L, whereas the concentration of total xylene in Well T9-4 exceeded the EPA Health Advisory Level. Second column confirmation was not conducted for xylene at Wells T9-1 and T9-2. The concentration of xylene in T9-4 (1,500 μg/L) could not be confirmed by second column due to interference with other

compounds. Detectable levels of petroleum hydrocarbons were present in Wells T9-4 (6.1 mg/L), T9-2 (0.17 mg/L), and T9-3 (0.70 mg/L). Lead was also detected in Wells T9-4, T9-1, and T9-3 at concentrations of 0.033, 0.026, and 0.0086 mg/L, respectively. All lead concentrations were below both state and NPDWR MCLs of 0.050 mg/L. EDB was not detected at Zone 9.

Significant Findings

Analytical results from monitoring wells at Zone 9 show the upgradient well (T9-3) to be free from detectable levels of volatile organic compounds and EDB. However, low levels of total petroleum hydrocarbons (0.59 mg/L) and trace concentrations of lead (0.0086 mg/L) were detected in this well. The presence of low levels of total petroleum hydrocarbons in the upgradient monitor well indicates there is a potential for low level contamination in this well. Lead concentrations detected in Well T9-3 were not high enough to indicate significant lead contamination in this well. Downgradient Wells T9-4 and T9-1 both contained detectable levels of benzene, ethylbenzene, toluene, and xylene, indicating contamination by POLs. In addition, Well T9-1 was found to contain detectable levels of solvents, i.e., 1,1,1-trichloroethane, 1,2-dichloropropane and 1,2-dichloroethane. It is significant to note that the chlorinated solvents present in T9-1 were absent from Well T9-4, which is upgradient of Well T9-1 (see Fig. 4.3-10). This suggests another possible source of these contaminants may exist, possibly at the oil/water separator adjacent to Building 83. Well T9-2, located downgradient of tank 515 to 520, contained trace levels of chloroform and petroleum hydrocarbons. These data indicate that Well T9-2, while being generally downgradient of Zone 9, is not within the direct path of the contaminant plume detected at T9-4. It appears likely that the source of the POL contamination detected in Well T9-4 is associated with the POL storage tanks (Tanks 505 through 508, Fig. 4.3-10) located immediately upgradient of Well T9-4.

The high levels of benzene, toluene, and xylene detected in Well T9-4 may be the result of a leaking underground storage tank at POL Area B. Highest overall levels of contamination at Zone 9 were detected in the downgradient Wells T9-1 and T9-4. Detectable levels of benzene at Zone 9 exceed both the NPDWR and state MCLs. Total xylene in Well T9-4 exceeded the EPA Health Advisory level. All other compounds detected in the surficial aquifer were present at levels below applicable state and EPA criteria and standards. Since the surficial aquifer is not used as a potable water source, an imminent health hazard from the consumption of contaminated ground water does not appear to exist at Zone 9. The areal and vertical extent of contamination in the ground water cannot be fully identified based on the four existing monitoring wells.

4.3.8 ZONE 10--"SHELL BANK" FIRE TRAINING AREA

Zone 10, referred to as the "Shell Bank" fire training area, was the original fire training area and is located northwest of the main instrument runway near Shoal Point Bayou (Fig. 4.3-11). This site was used from 1943 to 1952, and again from 1968 to 1980.

Zone 10 was a main repository for POL waste from industrial operations at Tyndall AFB in the past. POL waste was transported to this area and deposited in two 20,000-gal storage tanks.

Standard procedure for the fire training exercises was to pour POL waste onto an old aircraft or simulated aircraft located in a bermed area, and then set the aircraft on fire. Most of the POL waste was consumed in the fire; however, some percolation into the ground water may have taken place. It was reported by one interviewee that POL waste was sometimes taken to fire training areas by flight line personnel and dumped into the bermed training area instead of the POL waste storage tank.

Results of the Phase II, Stage 1 investigations showed detectable levels of TOX, DOC, and total phenolics to be present at this zone.

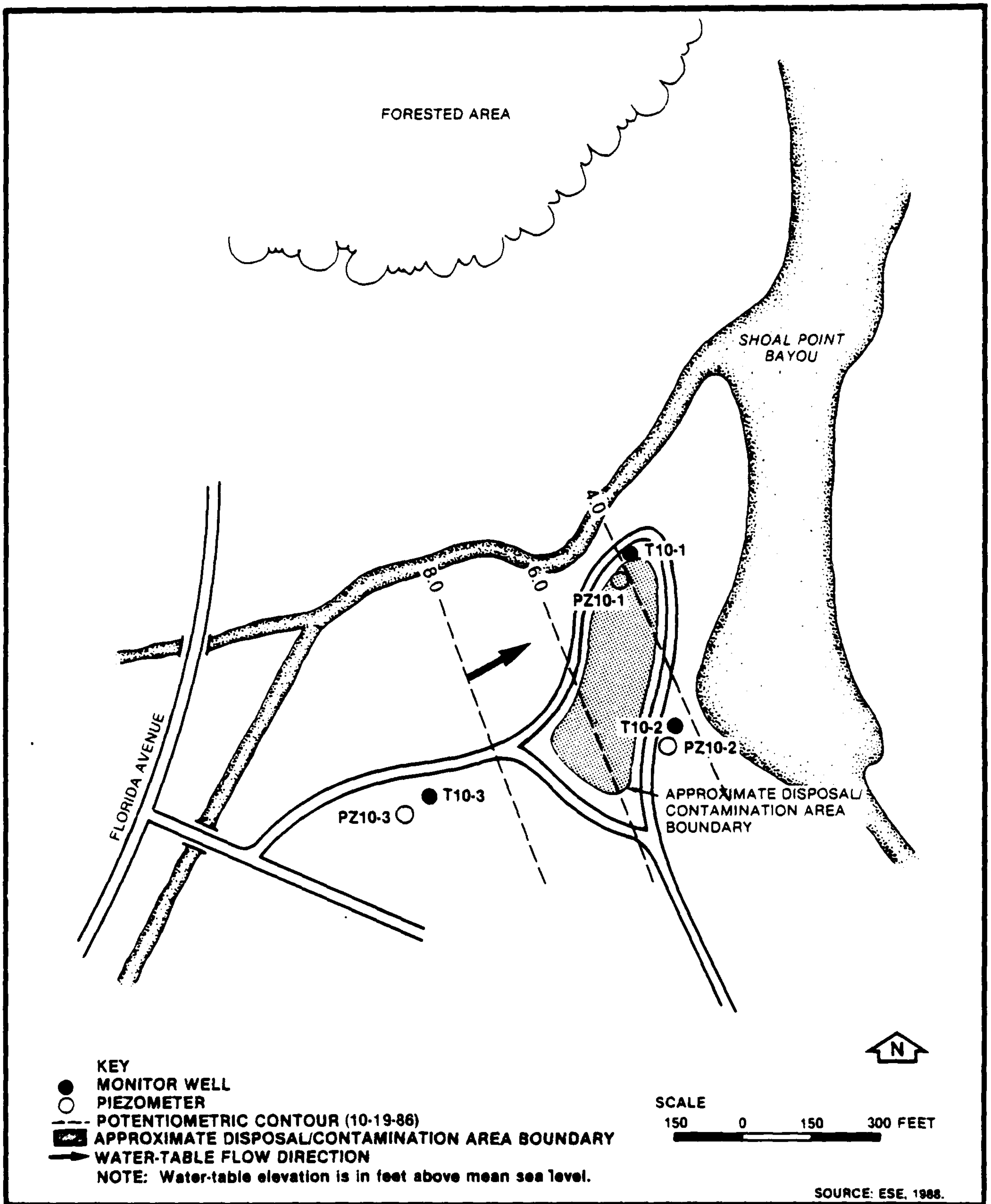

Figure 4.3-11
SITE MAP FOR ZONE 10—
"SHELL BANK" FIRE TRAINING AREA

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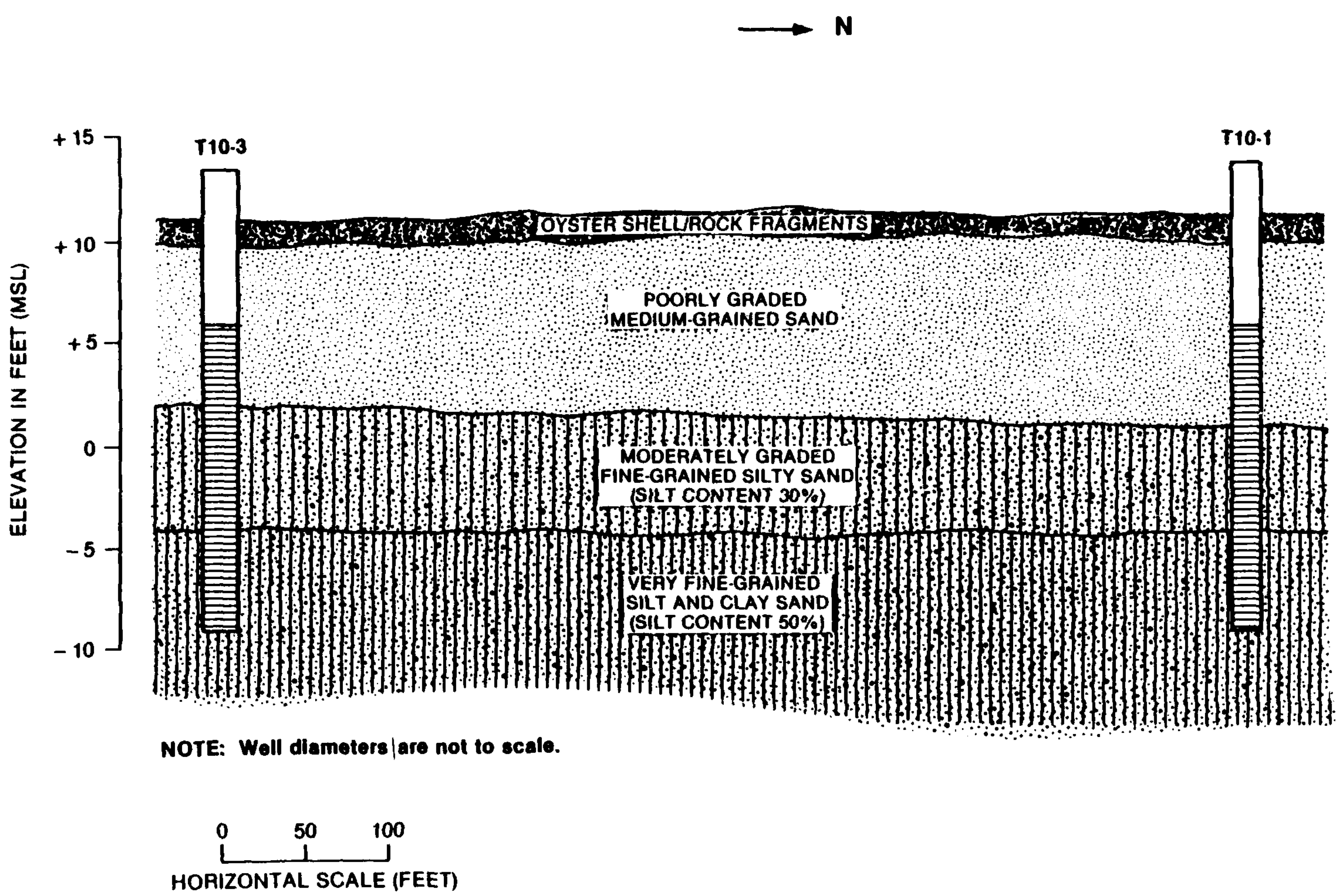
One upgradient monitor well (T10-3) and two downgradient monitor wells (T10-1 and T10-2) were installed at Zone 10. The locations of the three monitor wells are depicted in Fig. 4.3-11. The three monitor wells were sampled to evaluate the quality of the shallow ground water in the vicinity and to determine whether contaminants were migrating from the site.

The sediments underlying Zone 10 generally consisted of fill, silty and clayey sands, and clean sands through the depths penetrated (see Fig. 4.3-12). Much of the area has been resurfaced, so the upper 1 to 2 ft is predominantly composed of oyster shells and rock fragments. This surficial horizon is underlain by moderately graded, fine-grained quartz sand to a depth of roughly 8.5 to 10 ft, below which the sediments grade to a silty and clayey sand. The sand in this lower unit is very fine- to fine-grained, with silt and clay content ranging from 15 to 50 percent, increasing downward to the base of the boreholes.

Water-table levels ranged from 4.0 to 8.6 ft above sea level. The elevation of the potentiometric surface of the shallow aquifer is mapped in Fig. 4.3-11. Ground water flow direction is to the east-northeast, discharging into Shoal Point Bayou. Due to the relatively deep level of the water table and the clayey nature of the screened interval, recharge to Wells T10-1 and T10-2 was very slow, and pumpage was conducted discontinuously during development and purging. Recharge to Well T10-3 was sufficient to allow continuous pumping at a rate of 1.9 gpm.

Detectable concentrations of various analytes found in ground water samples at Zone 10 are presented in Table 4.3-8. Ground water samples from three monitoring wells at Zone 10 were analyzed for specific conductance, pH, purgeable organics, acid extractable organics, petroleum hydrocarbons, and lead.



SOURCE: ESE, 1988.

Figure 4.3-12
ZONE 10 — SHALLOW GEOLOGIC CROSS SECTION

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Table 4.3-8. Analytical Results for Ground Water Samples with Detectable Levels of Contaminants from Zone 10

Parameter	Ground Water				Detection Limits	NPDWR Wells
	T10-1	T10-2	T10-3	T10-3+		
pH field (standard units)	6.40	5.40	5.2			
Specific conductivity (umhos/cm)	453	152	57			
Chloroethane (ug/L)	ND	0.54	ND	ND	0.050	
Chloromethane (ug/L)	ND	ND	ND	0.10	0.050	
1,1-Dichloroethane (ug/L)	ND	10	ND	ND	0.050	
1,2-Dichloroethane (ug/L)	ND	0.080	ND	ND	0.050	5(3)
Trans-1,2-Dichloroethene (ug/L)	ND	0.17**	ND	ND	0.050	
1,1-Dichloroethylene (ug/L)	ND	0.13	ND	ND	0.050	7
Benzene (ug/L)	ND	34	ND	ND	0.50	5(1)
Ethylbenzene (ug/L)	ND	0.85*	ND	ND	0.50	
Lead (mg/L)	0.022	ND	ND	ND	0.0031	0.050 (0.050)

Notes: ND = not detected.
All other parameters analyzed at Zone 10 were below analytical detection limits.
Complete analytical results for Zone 10 are presented in Appendix R.
Values in parentheses are State of Florida MCLs.

*Single-column quantification, unable to confirm by second column due to interference (see Sec. 4.2).
+Field duplicate.
**Primary column indicates 12 ug/L of total 1,2-dichloroethene; however, the secondary column shows the major portion of the peak to probably be cis 1,2-dichloroethene while confirming a level of 0.17 ug/L of trans-1,2-dichloroethene.

Source: ESE, 1988.

Values for pH ranged from 5.2 to 6.4, all within the range observed at Tyndall AFB. Specific conductance values at Zone 10 varied from 57 umhos/cm at the upgradient Well T10-3 to 453 umhos/cm at Well T10-1. Specific conductance was within natural background levels, with the elevated level at Well T10-1 due to its close proximity to Shoal Point Bayou.

Monitor Well T10-3 was located upgradient of the "Shell Bank" fire training area based on interpretation of historic aerial photographs of the site and the potentiometric surface of the surficial aquifer at this zone. Results for all analyses were below analytical detection limits at this well.

Well T10-1, located at the northern downgradient end of the fire training area, was free from contamination with the exception of low levels of lead (0.022 mg/L). The lead concentration detected at Well T10-1 was below the state and NPDWR MCLs of 0.050 mg/L and was not indicative of significant ground water contamination at this site.

Monitor Well T10-2, located downgradient of the fire training area, was found to contain chlorinated solvents and their degradation products as well as detectable levels of benzene. Ethylbenzene was detected in Well T10-2 but could not be confirmed by second column confirmation due to interference. Chloroethane and 1,1-dichloroethane were present in Well T10-2 at concentrations of 0.54 and 10 μg/L, respectively. There are currently no state or Federal drinking water standards for these compounds. Although no specific information was found on the toxicity of chloroethane to humans or aquatic life, the toxicity of other chlorinated ethanes generally declines with decreasing chlorine content. Therefore, chloroethane is probably less toxic than 1,2-dichloroethane, which has a state MCL of 3 μg/L and an NPDWR MCL of 5 μg/L. Sax (1979) lists chloroethane as the least toxic of all chlorinated hydrocarbons. The level of 1,1-dichloroethane detected in Well T10-2 (10 μg/L) was well

below the EPA calculated maximum dose tolerable for chronic exposure of 4.05 mg/L (assuming an average human consumption of 2 L of water per day). The compound 1,1-dichloroethylene was present in Well T10-2 at a concentration of 0.13 μg/L, below the NPDWR MCL of 7 μg/L. Benzene was detected in Well T10-2 at a concentration of 34 μg/L, above the NPDWR MCL of 5 μg/L and the state MCL of 1 μg/L. Benzene was not detected in the other two monitor wells at this zone.

No other contaminants were detected at Zone 10 during the Phase II, Stage 2 investigations, although the samples were not analyzed for EP toxicity. A screening analysis for total phenolics during the Phase II, Stage 1 investigation showed concentrations of total phenolics ranging from 6 to 13 μg/L in ground water samples for four backhoe test pits. These backhoe test pits were located through the center of Zone 10 as shown on Figure 4 (page 1-11) of the Phase II Stage 1 report. Analysis of specific phenolic compounds (EPA Method 604) conducted during the current investigation showed all phenolic compounds to be below analytical detection limits.

The analytical method used during the Stage 1 investigation was a screening technique which does not differentiate betweeen naturally occurring and synthetic phenolic compounds. Therefore, the concentration of total phenolic compounds reported in the Stage 1 report included naturally occurring phenolics. The analytical method used during the Stage 2 investigation was selective for specific phenolic compounds (priority pollutant phenols) and did not detect naturally occurring phenolic compounds.

Significant Findings

Well T10-1, located upgradient of Zone 10, was free of contaminants with the exception of a low level of lead (0.022 mg/L). The lead concentration in this well was well below the state and NPDWR MCLs and was not a sign of significant ground water contamination. Well T10-3, located upgradient of Zone 10, was free of contaminants. The downgradient monitor well T10-2, located near Shoal Point Bayou did, however, contain detectable levels of chlorinated solvents (chloroethane,

1,1-dichloroethane, 1,1-dichloroethylene, and 1,2-dichloroethane). All of these compounds were present at low levels below their respective state and Federal water quality standards. Well T10-2 also contained detectable levels of benzene (34 μg/L) in excess of the state and NPDWR MCLs.

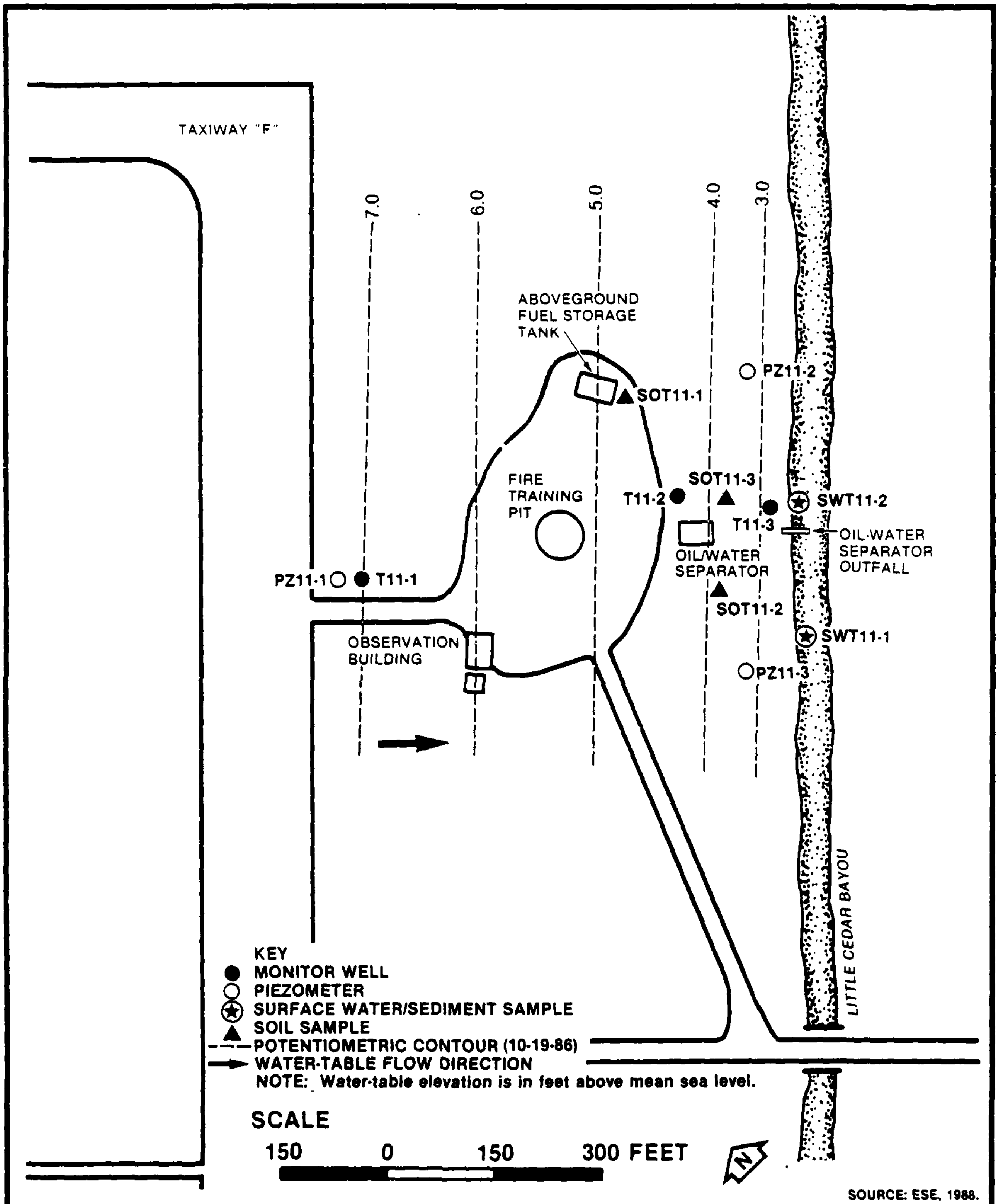
Results for Zone 10 indicate low level contamination of the surficial aquifer in the area of Well T10-2 for chlorinated solvents and benzene. The areal extent of the contamination appears to be limited to this area based on existing ground water quality data. Since the surficial aquifer is not used as a potable water source, an imminent human health hazard from the consumption of contaminated ground water does not appear to exist at Zone 10. There are no on-base wells within 1,000 ft of Zone 10. East Bay separates Zone 10 from all off-base wells, a distance greater than 1.5 miles.

4.3.9 ZONE 11--ACTIVE FIRE TRAINING AREA

This previously uninvestigated site has been in use since 1981 as a fire training area (see Fig. 4.3-13). Structures at the site include a fuel storage tank, a concrete lined training pit where fires are set and extinguished, and an oil/water separator which drains surface runoff away from the adjacent air field, and discharges wastewater to Little Cedar Bayou.

Soil borings were collected at three locations within Zone 11 where spills had visibly impacted the surface vegetation and soil. The locations of the soil borings are depicted in Fig. 4.3-13.

Sediment and surface water samples were collected from Little Cedar Bayou at two locations, which are depicted in Fig. 4.3-13. One location was immediately adjacent to the outfall from the oil/water separator discharge pipe, whereas the other location was upstream from the discharge outfall. These samples were collected to evaluate the impact of the oil/water separator, on Little Cedar Bayou.



SOURCE: ESE, 1988.

Figure 4.3-13
SITE MAP FOR ZONE 11 — ACTIVE FIRE TRAINING AREA

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One upgradient monitor well (T11-1) and two downgradient monitor wells (T11-2 and T11-3) were installed at Zone 11 in order to develop an adequate monitor well network for ground water sampling. The locations of the three monitor wells are depicted in Fig. 4.3-13.

The sediments underlying Zone 11 generally consisted of unconsolidated clean sands and silty sand through the depths penetrated. The upper 8 to 10 ft of sediments was composed of very fine- to coarse-grained, poorly to moderately graded, quartz sand with silt contents ranging from 0 to 10 percent. The underlying sediments were similar, with increased silt content ranging from 10 to 20 percent.

Water-table levels measured in the monitor wells ranged from 2.6 to 7.0 ft above sea level, with the elevation of the potentiometric surface mapped in Fig. 4.3-13. Ground water flow direction was to the southeast, discharging into Little Cedar Bayou. Recharge was slow to Wells T11-2 and T11-3 during development and purging, due to the clayey nature of the screened interval, and would not facilitate continuous pumping.
Well T11-1 pumped continuously at a rate of roughly 3.0 gpm.

Detectable concentrations of various analytes found in ground water samples at Zone 3 are presented in Table 4.3-9. Ground water and surface water samples were analyzed for pH, specific conductance, purgeable organics, acid extractable organics, petroleum hydrocarbons, and lead. In addition, soil and sediment samples from Zone 11 were analyzed for purgeable organics, petroleum hydrocarbons, and lead.

Ground water pH values ranged from 4.9 at Well T11-1 to 6.5 at Well T11-3. Specific conductance values at Zone 11 ranged from 159 umhos/cm at Well T11-1 to 906 umhos/cm at Well T11-3. The elevated specific conductance encountered in Well T11-3 was due to its close proximity to Little Cedar Bayou, a brackish waterway which is connected to East Bay.

Table 4.3-9. Analytical Results for Ground Water, Surface Water, Sediment, and Soil Samples with Detectable Levels of Contaminants from Zone 11

Parameter	Ground Water			Surface Water		Detection	NPDWR	Sediment (mg/kg)**		Soil (mg/kg)**		
	T11-1	T11-2	T11-3	SWT11-1	SWT11-2	Limits++	MCLs+	SDT11-1	SDT11-2	SOT11-1	SOT11-2	SOT11-3
pH field (std. units)	4.9	5.3	6.5	7.0	6.8			NA	NA	NA	NA	NA
Specific conductivity (umhos/cm)	159	236	906	2,700	2,680			NA	NA	NA	NA	NA
Chloroform (ug/L)	ND	ND	ND	0.050*	0.050*	0.050	100(100)	<0.11	<0.11	0.088	<0.088	<0.085
Chloromethane (ug/L)	ND	ND	0.49*	ND	ND	0.050		<0.29	<0.30	<0.23	<0.22	<0.23
T-1,2-Dichloroethene (ug/L)	ND	ND	<0.25	0.22*	0.18*	0.050		<0.11	<0.11	<0.087	<0.80	<0.085
Trichloroethene (ug/L)	ND	ND	0.45*	0.085	0.080	0.050	5(3)	<0.13	<0.30	<0.10	<0.095	<0.010
Benzene (ug/L)	1.7	ND	35	ND	ND	0.50	5(1)	<0.30	<0.50	4.9	<0.22	<0.23
Ethylbenzene (ug/L)	ND	ND	9.0*	ND	0.84*	0.50		<0.49	<0.41	22	<0.36	<0.38
Toluene (ug/L)	ND	ND	12	0.61*	ND	0.50		<0.41	<0.41	40	<0.30	<0.32
M-Xylene (ug/L)	NA	NA	NA	NA	NA			<0.41	<0.41	72	<0.30	<0.32
O,P-Xylene (ug/L)	NA	NA	NA	NA	NA			<0.41	<3.2	74	<0.30	<0.32
Lead (mg/L)	0.056	0.029	ND	ND	ND	0.0031	0.050(0.050)	5.1	3.2	1.8	2.9	0.52
Petroleum Hydrocarbons (mg/L)	ND	0.12	ND	0.26	0.23	0.10		170	75	1,200	260	27,000

Notes: ND = not detected.
NA = not analyzed.
All other parameters analyzed at Zone 11 were below analytical detection limits.
Complete analytical results for Zone 11 are presented in Appendix R.
Values in parentheses are State of Florida MCLs.
Analyses for total petroleum hydrocarbons for samples SDT11-1 and SDT11-2 exceeded the 28-day holding time by 1 day.

*First-column quantification, unable to confirm by second column due to interference.
+MCLs apply only to water samples.
**All sediment and soil results are reported in mg/kg.
++Detection limits apply to water samples only.

Source: ESE, 1988.

Based on the water level results presented in Appendix K and illustrated on Figure 4.3-13, Well T11-1 is upgradient of the fire training pit and Wells T11-2 and T11-3. Tidal influences may play a role in site characteristics; however, the water-level measurements recorded were insufficient to determine tidal effects. Analytical results for the ground water sample from this well indicate the presence of benzene at a concentration of 1.7 µg/L, which is above the state MCL but below the NPDWR MCL. Lead was also detected in this well at a concentration of 0.056 mg/L. The concentration of lead in Well T11-1 exceeded both the state and NPDWR MCLs of 0.050 µg/L. The lead and benzene concentrations observed in Well T11-1 suggest that an upgradient source of contamination may exist; however, there is no information available for confirmation.

Well T11-2, located downgradient of the lined fire training pit, contained low levels of lead (0.029 mg/L) and total petroleum hydrocarbons (0.12 mg/L). The lead concentration in Well T11-2 was below the state and NPDWR MCLs and was not an indication of significant contamination in Well T11-2. No other contaminants were detected in Well T11-2.

Monitor Well T11-3 was located downgradient of the fire training pit between Well T11-2 and Little Cedar Bayou. Chloromethane was detected in the water sample from Well T11-3 but could not be confirmed due to interference. Trichloroethene was also detected at Well T11-3 at a concentration of 0.45 µg/L but could not be confirmed by second-column analysis. Benzene was detected in Well T11-3 at 35 µg/L, which exceeded the state MCL of 1 µg/L and the NPDWR MCL of 5 µg/L. Ethylbenzene was detected at a concentration of 9.0 µg/L but could not be confirmed by second-column analysis. Toluene was detected and confirmed in Well T11-3 at a concentration of 12 µg/L, below the EPA Health Advisory of 2,000 µg/L. Total petroleum hydrocarbons and lead were not detected in Well T11-3. The source of interference for chloromethane, trichloroethene, and ethylbenzene is not known (see Section 4.2).

Acid extractable organics were not detected in ground water samples from this zone.

Surface water samples were collected from Little Cedar Bayou at two locations. One location (SWT11-1) was located approximately 150 ft northwest of the oil/water separator discharge outfall, whereas the other location (SWT11-2) was located immediately adjacent to the outfall. Samples were collected from these sites to evaluate the impact of the oil/water separator on Little Cedar Bayou.

The pH values obtained from the two surface water samples collected from Little Cedar Bayou were 6.8 and 7.0, within the state Class III surface water quality standard of 6.5 to 8.5. Specific conductance was similar at both sites, with values of 2,700 umhos/cm and 2,680 umhos/cm at SWT11-1 and SWT11-2, respectively. These values reflect the saline nature of Little Cedar Bayou which is connected to East Bay.

Chloroform was detected in both surface water samples at a concentration of 0.050 µg/L, but could not be confirmed by second-column analysis.

Trichloroethene was detected in both surface water samples from Little Cedar Bayou. Concentrations of trichloroethene ranged from 0.085 µg/L at SWT11-1 to 0.080 µg/L at SWT11-2; both levels were below the state MCL (3 µg/L) and the NPDWR MCL (5 µg/L). Concentrations of trichloroethene detected in Little Cedar Bayou were below the lowest acute toxicity levels for aquatic life reported in the EPA Ambient Water Quality Criteria documents. Trans-1,2-dichloroethene was detected in both surface water samples, but could not be confirmed by second-column analysis.

Ethylbenzene was detected at SWT11-2 at a concentration of 0.84 µg/L, below the lowest acute toxicity level for aquatic life of 430 µg/L reported in the Ambient Water Quality Criteria documents. The presence

of ethylbenzene in surface water from this zone could not be confirmed by second-column analysis. Toluene was detected at SWT11-1 at 0.61 µg/L, which is also below the lowest acute toxicity level for aquatic life of 6,300 µg/L. As with ethylbenzene, the presence of toluene could not be confirmed by second-column confirmation. Low levels of total petroleum hydrocarbons ranging from 0.23 to 0.26 mg/L were detected in Little Cedar Bayou.

Analyses of surface water samples indicate the presence of low levels of trichloroethene and POL contamination. Phenolic contaminants were not detected in surface water samples from Little Cedar Bayou.

Two sediment samples (SDT11-1 and SDT11-2) were collected along with the surface water samples from Little Cedar Bayou. Volatile organic compounds were not detected in the sediment samples. Sediment samples were found to contain total petroleum hydrocarbons at concentrations of 170 and 75 mg/kg at SDT11-1 and SDT11-2, respectively. In addition, lead was detected at concentrations of 5.1 and 3.2 mg/kg. Total petroleum hydrocarbon concentrations in sediment samples indicate the possibility of low level POL contamination in Little Cedar Bayou.

Soil borings were obtained from three locations within Zone 11 where spills had visibly impacted the surface vegetation and soil. Soil sample SOT11-1 was obtained immediately downgradient of the fuel storage tank, SOT11-2 was obtained immediately south of the oil/water separator, and SOT11-3 was located between the fire training pit and Little Cedar Bayou. No volatile organic compounds were detected in soil sample SOT11-2 near the oil/water separator, or SOT11-3 between the fire training pit and Little Cedar Bayou. Detectable levels of chloroform (0.088 mg/kg), benzene (4.9 mg/kg), ethylbenzene (22 mg/kg), toluene (40 mg/kg), and xylene (146 mg/kg) were, however, detected in SOT11-1, located adjacent to the fuel tank. Total petroleum hydrocarbons were detected in all soil samples with concentrations of 260 mg/kg at SOT11-2, 1,200 mg/kg at

SOT11-1, and 27,000 mg/kg at SOT11-3. Detectable levels of lead were also present in all soil samples from Zone 11. Lead concentrations ranged from 0.52 mg/kg at SOT11-3 to 1.8 mg/kg at SOT11-1 to 2.9 mg/kg at SOT11-2. Lead concentrations in soil samples were highest at SOT11-2 (near the oil/water separator), and lowest at SOT11-3 (between the fire training pit and Little Cedar Bayou).

Significant Findings

Ground water samples from the surficial aquifer at Zone 11 contained low levels of lead and total petroleum hydrocarbons. Benzene was also detected in Well T11-3 at a concentration of 35 μg/L, exceeding the state and NPDWR MCLs. The lead concentration in Well T11-1 (0.056 μg/L) exceeded the state and NPDWR MCLs of 0.050. All other contaminants in ground water samples from Zone 11 are below their respective state and federal standards.

The overall highest concentrations of contaminants were detected in Well T11-3, located downgradient of the active fire training area, near Little Cedar Bayou. The highest concentration of benzene (35 μg/L) was detected in T11-3, whereas the highest concentration of lead (0.056 μg/L) was detected in T11-1, the upgradient well. Benzene (1.7 μg/L) was also detected in the upgradient monitor well. The contaminants detected in the upgradient monitor well are an indication that low level POL contamination is present in this area.

The results of chemical analyses of ground water samples from Zone 11 indicate low levels of contamination by chlorinated solvents, petroleum-related hydrocarbons, and lead. Since the surficial aquifer is not used as a source of potable water, an imminent human health hazard associated with the consumption of contaminated ground water does not appear to exist at Zone 11. All base supply wells are located at least 4,000 ft from Zone 11.

Surface water samples from Little Cedar Bayou, adjacent to and downgradient of the active fire training area, contained low levels of trichloroethene and total petroleum hydrocarbons. All contaminants in Little Cedar Bayou were detected at levels below applicable state and federal standards.

Sediment samples from Little Cedar Bayou were found to contain lead (5.1 and 3.2 μg/kg) and total petroleum hydrocarbons, (170 and 75 mg/kg). No other contaminants were detected in the sediment samples.

The soil sample from the area around the above ground fuel storage tank was found to contain benzene (4.9 mg/kg), ethylbenzene (22 mg/kg), toluene (40 mg/kg), xylene (146 mg/kg), lead (1.8 mg/kg), and total petroleum hydrocarbons (1,200 mg/kg). Soil in this area had the highest concentrations of contaminants with the exception of sample SOT 11-3 located between the fire training pit and Little Cedar Bayou, which contained 27,000 mg/kg of total petroleum hydrocarbons.

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5.0 ALTERNATIVE MEASURES AND CONCLUSIONS

5.1 ALTERNATIVE MEASURES

Three categories of alternatives are possible for the sites investigated:

I. Take no further action;

II. Conduct further monitoring to determine the need, if any, of cleanup; or

III. Undertake corrective actions to mitigate any contamination.

Category I (No Further Action) is appropriate for sites where there is little, if any, evidence to indicate that the site is or will ever be a source of significant contamination. Reasonable judgments must be made so that resources can be allocated to sites that have the highest potential for environmental or human health problems.

Category II (Additional Monitoring) is appropriate where insufficient evidence exists to place a site in either Category I or III. This category should be utilized with care since there is some risk that delay could allow contamination to spread and worsen the problem. That goal should be to gather enough evidence in a timely manner to resolve the question of whether or not the site should be cleaned up.

Category III (Mitigation) is appropriate where there is clear indication that current or future human or environmental problems will exist. The priority for actions would depend on the magnitude of the threat and whether that threat was current or future. Mitigative actions may include (but are not limited to) removal, containment, treatment, or stabilization of the contamination.

5.1.1 CATEGORY I (NO FURTHER ACTION)

Category I has been judged not to be an appropriate alternative for any of the Phase II, Stage 2 sites at Tyndall AFB.

5.1.2 CATEGORY II (ADDITIONAL MONITORING)

Category II has been judged to be the appropriate alternative for the following Phase II, Stage 2 sites at Tyndall AFB.

1. Zone 2--Lynn Haven DFSP,
2. Zone 3--POL Area A,
3. Zone 5--Small Arms Repair Area,
4. Zone 6--Highway 98 Fire Training Area,
5. Zone 7--Southeast Runway Extension Burial Site,
6. Zone 8--"6000" Area Landfill,
7. Zone 10--"Shell Bank" Fire Training Area, and
8. Zone 11--Active Fire Training Area.

The following criteria are recommended for additional analyses for these zones:

1. Analytical results for ground water samples from the zones indicate the presence of one or more contaminant in the surficial aquifer.
2. Available data for the site are insufficient to adequately define the areal or vertical extent of the contamination.

5.1.3 CATEGORY III (IMPLEMENTATION OF CORRECTIVE ACTIONS)

Category III has been judged to be the appropriate alternative for the following Phase II, Stage 2 site at Tyndall AFB.

1. Zone 9--POL Area B.

Criteria for recommending implementation of corrective actions for these zones are:

1. Analytical results for ground water samples from the zones indicate the presence of one or more contaminants in the surficial aquifer at levels exceeding the NPDWR or state MCL.
2. Analytical results indicate a high likelihood of an ongoing source of contamination such as a leaking tank or ruptured pipe.
3. An evaluation of potential human exposure to contamination through contact with contaminated soils or through supply wells resulted in the determination that an imminent human health hazard may exist at the site.

5.2 CONCLUSIONS

Nine zones were investigated during the Tyndall AFB Phase II, Stage 2 study. These investigations were performed to confirm the existence of contaminants at each of the zones and to assess potential migration of contaminants in the surficial aquifer and adjacent surface waters. The following conclusions have been developed based on assessments for each zone.

5.2.1 ZONE 2--LYNN HAVEN DFSP

Low levels of total petroleum hydrocarbons were detected in all but two ground water samples from monitor wells located downgradient of the areas of suspected contamination at concentrations ranging from 0.09 to 0.78 mg/L. Monitor wells at this site also contained trace levels of two volatile organic compounds [trichlorofluoromethane (0.010 µg/L), and methylene chloride (0.095 µg/L). Since methylene chloride was detected at a level just slightly exceeding the analtyical detection limit and this compound is used in the laboratory as an extraction solvent and is known to be a common laboratory contaminant, it is likely that the concentration detected at Zone 2 may be an artifact of sample handling. Low concentrations of lead ranging from 0.0043 to 0.0086 mg/L were also detected in two monitor wells at this zone. Lead concentrations were below the state and NPDWR MCLs in all ground water samples from this site.

Benzene (0.54 µg/L) and toluene (0.80 µg/L) were detected in the surface water sample collected from the drainage ditch leading from the oil/water separator into East Bay. Petroleum hydrocarbons were also present in the surface water sample, at a level below the State of Florida Class II water quality criterion of 5 mg/L. Lead was not detected in the surface water sample from the ditch leading from the oil/water separator.

A sediment sample collected from the drainage ditch leading from the oil/water separator to East Bay contained detectable levels of total petroleum hydrocarbons (35,000 mg/kg) and lead (98 mg/kg), indicating possible sediment contamination from the oil/water separator.

Based on these results, only very low levels of residual POL contamination appear to exist in the surficial aquifer underlying Zone 2. Since the surficial aquifer is not being utilized as a potable water source, the contamination at this zone does not appear to present an imminent human health hazard from the consumption of contaminated ground water. All contaminants detected in ground water samples from this zone were at levels below applicable state surface water quality criteria. Therefore, ground water seepage from this zone into East Bay will not result in violations of surface water quality criteria. It is likely that the majority of POL disposed at Zone 2 has undergone degradation and currently is not migrating offsite.

5.2.2 ZONE 3--POL AREA A

Ground water samples collected from Zone 3 contained low levels of six volatile organic compounds (bromodichloromethane, chloroform, chloromethane, methylene chloride, trichlorofluoromethane, and toluene). It is possible that methylene chloride, a common laboratory solvent, was an artifact and is not present in the surficial aquifer at Zone 3. Methylene chloride slightly exceeded the EPA ambient water quality criteria of 0.19 µg/L for the protection of human health. All other volatile organic contaminants were below applicable state and federal criteria. Low concentrations of lead were detected in all wells at this zone with the exception of T3-5. All lead concentrations detected at Zone 3 were below the state and NPDWR MCL of 0.050 mg/L with the exception of Well T3-3, which had a lead concentration of 0.17 mg/L. Results of the ground water sampling program at Zone 3 showed only minor POL related and volatile organic contamination of the surficial aquifer. The source of the volatile organic contaminants at Zone 3 is unknown

based on reported past practices at this site. A review of QC data for this site, including laboratory method blanks, shows the volatile organics not to be analytical artifacts due to laboratory contamination with the possible exception of methylene chloride. Methylene chloride (possible laboratory artifact) and lead were the only contaminants found to slightly exceed state and EPA criteria. Since lead concentrations exceeded the MCL in only one well and methylene chloride was detected in only one well, the overall extent of contamination at Zone 3 appears to be limited in areal extent. Because the surficial aquifer is not used as a source of drinking water, an imminent health hazard from the consumption of contaminated ground water does not appear to exist at Zone 3. A water supply well located at Zone 3 is screened in the Floridan Aquifer at a depth of 315 to 600 ft. This well is currently classified as inactive. Analytical results from a water sample taken in 1984 show the well to be free of lead contamination.

5.2.3 ZONE 5--SMALL ARMS REPAIR AREA

Ground water samples from Zone 5 contained detectable levels of two volatile halogenated organic compounds (bromodichloromethane and chloroform). Both contaminants were below the state and NPDWR MCLs for total THMs. Phenolic compounds were not detected in any ground water sample from Zone 5. Ground water samples from Zone 5 did not show evidence of contamination by organic compounds in excess of state or federal MCLs.

Nine priority pollutant metals were detected in ground water samples, with concentrations of arsenic, and chromium, exceeding state and NPDWR MCLs. Concentrations of beryllium and thallium exceeded the EPA Ambient Water Quality Criteria for the protection of human health. Concentrations of copper, lead, silver, zinc, and mercury were all detected in ground water samples from this zone but were below their respective state and NPDWR MCLs and were present at very low levels. Nickel was also detected at Zone 5 at a concentration well below the EPA Health Advisory Level.

Since the surficial aquifer is not being used as a potable source, contamination at this site does not appear to present an imminent human health hazard from the consumption of contaminated ground water. The limited number of monitor wells (three) sampled during the Phase II, Stage 2 study was not sufficient to fully define the areal and vertical extent of contamination at this zone. Both upgradient and downgradient monitor wells were found to contain priority pollutant metals in excess of their state and NPDWR MCLs.

5.2.4 ZONE 6--HIGHWAY 98 FIRE TRAINING AREA

A total of six volatile organic compounds, including chlorinated solvents, benzene, and toluene, were detected in ground water samples from Zone 6. All volatile organic compounds were below applicable state and EPA criteria with the exception of benzene, which exceeded the state and NPDWR MCLs. Total petroleum hydrocarbons and lead were detected in ground water samples at Zone 6. All lead concentrations were below the state and NPDWR MCLs of 0.050 mg/L. Phenolic contaminants were not detected in any Zone 6 monitor well.

Since the surficial aquifer is not presently used as a potable water source, an imminent human health hazard from the consumption of contaminated ground water does not appear to currently exist. The surficial aquifer may potentially be used for drinking water in the future and should be protected. The areal and vertical extent of contaminants observed in ground water at this zone cannot be fully defined based on the existing monitor well network. Both upgradient and downgradient monitor wells were found to contain detectable levels of contaminants at Zone 6.

5.2.5 ZONE 7--SOUTHEAST RUNWAY EXTENSION BURIAL SITE

Results of ground water samples from Zone 7 indicate the presence of volatile organic compounds, phthalates, and priority pollutant metals. All organic compounds detected were present at trace levels below state and EPA water quality criteria. Six priority pollutant metals

were detected at this zone, with concentrations of arsenic slightly exceeding their NPDWR and state MCLs. Beryllium and thallium were detected at levels slightly above the EPA ambient water quality criteria for the protection of human health. Chromium, nickel, and zinc were present in ground water samples from this zone but were below applicable state and EPA criteria.

Base Well 11, located at the Alert Facility adjacent and downgradient of the area of contamination at Zone 7, was found to contain 1,1,1-trichloroethane, bis(2-ethylhexyl)phthalate, thallium, and zinc. All contaminants detected at Base Well 11 were below applicable state and NPDWR MCLs and EPA ambient water quality criteria for the protection of human health with the exception of thallium. Base Well 11 is used as a water source for the Alert Facility, with bottled water supplied for drinking purposes due to a high dissolved solids content and poor taste quality of the well water. Base Well 11 is screened in the surficial aquifer at a depth of 100 to 115 ft.

Since the surficial aquifer is used as a water source at the Alert Facility, the possibility of a human health hazard does appear to exist at Zone 7.

Based on the results from the limited number of monitor wells sampled at this zone, the areal and vertical extent of contamination at this site cannot be adequately assessed at this time.

5.2.6 ZONE 8--"6000" AREA LANDFILL

Results of the surface geophysical survey conducted at this zone indicate the presence of buried metallic objects within the landfill boundary. Clear evidence of a contaminant plume associated with the landfill could not be established by the geophysical survey. Soil conductance values were relatively low throughout the entire landfill area.

Four volatile organic compounds (i.e., chloroform, chloromethane, 1,2-dichloropropane, and trichlorofluoromethane) were detected at Zone 8. Bis(2-ethylhexyl)phthalate and di-n-octylphthalate were also detected at Zone 8. All organic compounds were present at levels below their respective state and NPDWR MCLs and EPA ambient water quality criteria for the protection of human health. A total of five priority pollutant metals were identified in ground water samples from Zone 8. Arsenic slightly excessed the state and NPDWR MCLs. Chromium, copper, silver, and zinc were also detected at this zone, but at levels below state and NPDWR MCLs. All monitor wells at Zone 8 were found to be free of detectable levels of phenolic compounds, pesticides, and PCBs.

Results of chemical analyses of ground water samples from this site do not indicate the presence of contamination in excess of state and NPDWR MCLs, with the exception of arsenic. The areal extent of contamination observed in ground water at this zone cannot be fully evaluates based on the present network of monitor wells. All three monitor wells at this zone were found to contain low levels of potential contaminants. Since the surficial aquifer is not used as a potable water source, an imminent health hazard from the consumption of contaminated ground water does not appear to exist at Zone 8.

5.2.7 ZONE 9--POL AREA B

Ground water samples from Zone 9 contained low levels of chloroform, 1,2-dichloroethane, 1,2-dichloropropane, and 1,1,1-trichloroethane. All of these contaminants were present at levels below applicable state and NPDWR MCLs and EPA ambient water quality criteria for the protection of human health. Detectable levels of benzene, ethylbenzene, and toluene were also present at this zone. Benzene was detected at a concentration of 270 μg/L at Well T9-4, whereas both ethylbenzene and toluene were detected at levels of 140 μg/L. Detectable levels of petroleum hydrocarbons and lead were also present at Zone 9. Well T9-4 contained the

highest levels of benzene, toluene, ethylbenzene, and petroleum hydrocarbons Well T9-4 is located downgradient from eight underground storage tanks located at POL Area B. Based on the elevated levels of petroleum-related contaminants in this well, it appears likely that a leak may exist in one or more of the underground storage tanks.

Analytical results for Zone 9 indicate the surficial aquifer is contaminated with low levels of chlorinated solvents and petroleum-related contaminants. Highest levels of chlorinated solvents were detected in Well T9-1 while the highest levels of benzene, ethylbenzene, toluene, xylene and petroleum hydrocarbons were detected in Well T9-4. Since the surficial aquifer is not used as a potable water source, an imminent health hazard from the consumption of contaminated ground water does not appear to exist at Zone 9. The areal and vertical extent of contamination in the ground water cannot be fully identified based on the four existing monitor wells.

5.2.8 ZONE 10--"SHELL BANK" FIRE TRAINING AREA

Volatile organic compounds, petroleum hydrocarbons, and lead were detected in ground water samples from Zone 10. Chloroethane, 1,1-dichloroethane, 1,2-dichloroethane, and 1,1-dichloroethylene, were all detected at concentrations below applicable state and EPA water quality criteria. Benzene was detected at a concentration of 34 μg/L, exceeding the state and NPDWR MCLs.

Contamination in the surficial aquifer appears to be restricted to the area around Well T10-2, downgradient of the suspected area of contamination. Contaminants in the surficial aquifer in this area are typical of these associated with fire training activities and waste POL (i.e., chlorinated solvents, benzene, petroleum hydrocarbons, and lead). Due to the proximity of Well T10-2 to Shoal Point Bayou (approximately 75 ft), the potential for contamination of adjacent surface waters by ground water seepage may exist at this site. Since the surficial aquifer

is not used as a potable water source, an imminent human health hazard associated with the consumption of contaminated ground water does not appear to exist at Zone 10. The areal extent of contamination in the ground water at this zone cannot be fully identified, based on the existing monitor wells.

5.2.9 ZONE 11--ACTIVE FIRE TRAINING AREA

Analytical results obtained for Zone 11 indicated the presence of waste POL contamination at low levels in both the surficial aquifer and Little Cedar Bayou.

Ground water samples from the surficial aquifer at Zone 11 contained lead, total petroleum hydrocarbons, benzene, and toluene. Benzene was detected at a concentration of 35 µg/L, exceeding state and NPDWR MCLs. Lead, at a concentration of 0.056 µg/L, was the only other contaminant detected in ground water samples from this zone that exceeded state or NPDWR MCLs. Contaminants detected at this zone were typical of those associated with fire training activities (i.e., POLs, various solvents, lead, and degreasing agents). No phenolic contaminants were detected at this zone. The level of ground water contamination observed at Zone 11 was low, with the highest concentrations detected in Well T11-3, located downgradient of the oil/water separator adjacent to Little Cedar Bayou. Monitor Well T11-2, located downgradient of the fire training pit but upgradient of the oil/water separator, contained only low levels of petroleum hydrocarbons and lead. Chlorinated solvents and benzene were not detected in this well. It appears that a source of ground water contamination exists downgradient of the fire training pit but upgradient of Well T11-3, possibly at the oil/water separator.

Since the surficial aquifer is not used as a source of potable water, an imminent human health hazard associated with the consumption of contaminated ground water does not appear to exist at Zone 11. All base supply wells are located at a distance of at least 4,000 ft from Zone 11.

Surface water samples from Little Cedar Bayou contained trichloroethene and total petroleum hydrocarbons. All contaminants detected in Little Cedar Bayou were present at low levels at both sampling points and were below applicable state and EPA criteria. Sediment samples from Little Cedar Bayou contained detectable levels of lead (3.2 and 5.1 mg/kg) and total petroleum hydrocarbons (74 and 170 mg/kg).

Soil borings were collected at three locations within Zone 11 where fuel spills had visibly impacted the surface vegetation and soil. Detectable levels of petroleum hydrocarbons (1,200 mg/kg), benzene (4.9 mg/kg), ethylbenzene (22 mg/kg), toluene (40 mg/kg), xylene (146 mg/kg), and lead (1.8 mg/kg) were present in the soil samples taken near the aboveground fuel storage tank.

The soil sample taken near the oil/water separator did not contain volatile organic compounds but did contain petroleum hydrocarbons (27,000 mg/kg) and lead (2.9 mg/kg). The third soil sample, taken downgradient of the fire training pit, contained petroleum hydrocarbons (260 mg/kg) and lead (2.9 mg/kg).

The results of soil borings taken from Zone 11 indicate petroleum-related soil contamination has taken place, the areal extent of which could not be fully determined based on the limited number of samples taken.

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6.0 RECOMMENDATIONS

This section presents recommendations for subsequent actions at Tyndall AFB on a site-by-site basis. These recommendations are based on results of ground water, surface water, sediment, and soil samples. Recommendations include continued monitoring and limited corrective actions. In addition, endangerment assessments are recommended to determine the public health and environmental impacts at all sites.

6.1 ZONE 2--LYNN HAVEN DFSP

This zone has been in operation since 1943. The results from this site show only low levels of petroleum related compounds, and the possibility of low concentrations of two volatile organics in the surficial aquifer. All concentrations were below state and Federal criteria. Although Zone 2 has a history of deposition of POL waste, signs of significant contamination was not found at Zone 2.

The direction of flow of the surficial aquifer is northeast toward North Bay and away from the town of Lynn Haven. Residents of Lynn Haven utilize private wells which are screened within the upper portion of the Floridan Aquifer. Based on the low level of contamination in the surficial aquifer, this site does not appear to present an imminent human health hazard associated with the consumption of contaminated ground water. Zone 2 has been assigned to Category II. If the need for clean up is established, the zone can be subsequently assigned to Category III and corrective actions undertaken. Otherwise, the zone can be placed in Category I. The following recommendations are made for the future management of this site.

1. A ground water sample from the surficial aquifer should be obtained from monitor well LH2-4 and analyzed for purgeable organics. This sample should be used to assess the presence of trichlorofluoromethane and methylene chloride previously detected in this well.

2. An additional monitor well should be installed near the area of suspected Bunker C fuel dumping. Ground water samples should be collected from this new well and all existing monitor wells and analyzed for purgeable organics and metals. Soil samples (from the Bunker C fuel dump site) should be collected and analyzed for purgeable organics and metals.
3. Elevated levels of petroleum hydrocarbons (35,000 mg/kg) and lead (98 mg/kg) were detected in the sediment sample taken from the drainage ditch which leads from the oil/water separator. It is recommended that three surface water and sediment sampling stations be located in North Bay in line with the drainage ditch. One sample should be taken at the shore, with the other samples taken at approximately 10-ft intervals offshore. These samples should be analyzed for petroleum hydrocarbons and metals to determine their distribution in the surface water and sediment.

6.2 ZONE 3--POL AREA A

This zone, which has been in operation since 1943, was found to contain low levels of volatile organics and lead. The concentration of lead in the ground water from Well T3-3 exceeded both Federal and state MCLs. All other contaminants, with the exception of methylene chloride which exceeded the EPA ambient water quality criterion of 0.19 µg/L, for the protection of human health, were found at levels below their respective state and Federal criteria. Since East Bay separates Tyndall AFB from potential off-base wells in the surficial aquifer and the direction of flow in the Floridan Aquifer is toward the Gulf of Mexico and away from Panama City, off-base migration of contaminants will not affect ground water supplies in Panama City. Since the surficial aquifer is not used as a source of drinking water, the site does not appear to present an imminent human health hazard due to the consumption of contaminated ground water. The site has been assigned to Category II. The following recommendations are made for future management of the site.

1. A confirmatory round of sampling is recommended for all monitor wells at this site. These samples should be analyzed for purgeable organics, petroleum hydrocarbons, and metals.
2. A sample from base supply Well 6A, located at Zone 3, should be analyzed for purgeable organics, petroleum hydrocarbons, and metals prior to use as a water source.
3. A new monitor well should be installed near the area of alleged sludge burial west of the storage tanks. This well should also be analyzed for purgeable organics, petroleum hydrocarbons, and metals. In addition, two soil samples from the area of alleged sludge burial should be collected and analyzed for purgeable organics, petroleum hydrocarbons, and metals.
4. Due to the concentration of lead found in Well T3-3 and the proximity of this well to Shoal Point Bayou (<50 ft), it is recommended that sediment and surface water samples be taken in Shoal Point Bayou. Three stations should be located in Shoal Point Bayou, in proximity to Well T3-3.

6.3 ZONE 5--SMALL ARMS REPAIR AREA

This zone, which was utilized for the disposal of waste paints and solvents, was operated from 1965 until 1972. Low levels of bromodichloromethane and chloroform were detected at Zone 5. This zone was found to contain concentrations of arsenic, and chromium exceeding state and NPDWR MCLs. Since East Bay separates Tyndall AFB from potential off-base wells and the direction of flow in the Floridan Aquifer is toward the Gulf of Mexico and away from Panama City, there is no likelihood that off-base migration of contaminants will affect ground water in Panama City. Also, the surficial aquifer is not used as a water supply on Tyndall AFB, with the exception of Base Well 11, which is located upgradient and several miles from Zone 5. As a result, this site

does not appear to present an imminent human health hazard due to the consumption of contaminated ground water. The site has been assigned to Category II. The following recommendations are made for the future management of this site.

1. A confirmatory round of sampling for priority pollutant metals is recommended for all three monitor wells at this site.
2. If the results of the confirmatory sampling for priority pollutant metals show concentrations exceeding state and Federal MCLs, a series of soil samples should be obtained from Zone 5 to identify the boundaries of the contamination source. Soil samples should be analyzed for priority pollutant metals.
3. Based on the results of the soil samples, one to three additional monitor wells should be installed to determine the areal extent of contamination.
4. Because supply Well 5A is located downgradient in the Floridan Aquifer at a distance of 500 ft from Zone 5, this well should be tested for priority pollutant metals before it is utilized as a supply well.

6.4 ZONE 6--HIGHWAY 98 FIRE TRAINING AREA

This zone was a main POL repository, and a fire training area from 1952 to 1968. The surficial aquifer within the zone was found to contain only low levels of volatile organics, petroleum hydrocarbons, and lead. Benzene was the only compound found in excess of state and Federal MCLs at this zone. No downgradient wells screened in the Floridan Aquifer are located at this site, so there is little chance of future contamination of existing on-base supply wells from contaminant migration. Since East Bay separates Tyndall AFB from potential off-base wells and, in addition, the direction of flow in the Floridan Aquifer is toward the Gulf of Mexico, away from Panama City, there is no likelihood that off-base migration of contaminants will affect ground water in Panama City. The site, therefore, does not appear to present an imminent human health hazard from the consumption of contaminated ground water. The following recommendations are made for the future management of this site, which has been assigned to Category II.

1. A confirmatory round of sampling should be conducted at all existing monitor wells. Samples should be analyzed for purgeable organics, petroleum hydrocarbons, and metals.
2. Due to the presence of contamination in Well T6-3, two additional monitor wells should be installed upgradient of T6-3 near Highway 98. These wells should be sampled for purgeable organics, petroleum hydrocarbons, and metals.
3. A series of soil gas measurements should be taken in the area between Highway 98 and Well T6-3. These samples should be used to identify the source of contamination in this area.
4. Soil samples should be taken in the area with the highest level of contamination as identified by the soil gas samples. The soil samples should be analyzed for petroleum hydrocarbons, metals, and purgeable organics.

6.5 ZONE 7--SOUTHEAST RUNWAY EXTENSION BURIAL SITE

This site was in operation from 1945 to 1965. Arsenic was present at concentrations slightly exceeding the NPDWR and state MCLs, with beryllium and thallium detected at concentrations slightly exceeding the EPA Ambient Water Quality Criteria for the protection of human health.

East Bay separates Tyndall AFB from potential off-base wells. The direction of flow in the Floridan Aquifer is toward the Gulf of Mexico and away from Panama City; therefore, there is no likelihood that off-base migration of contaminants will affect ground water in Panama City. The surficial aquifer is used as a water supply at the Alert Facility, adjacent to Zone 7 via Base Well 11, which is screened at a depth of 110 to 115 ft. This zone has been placed in Category II and additional sampling recommended to determine if the metals concentrations detected present a threat to Base Well 11. The following recommendations are made for the future management of this site:

1. Existing monitor wells should be sampled for purgeable organics, base/neutral extractable organics, and priority pollutant metals, as a confirmatory step. A sample from Base Well 11 should also be collected and analyzed for purgeable organics, base/neutral extractable organics, and priority pollutant metals.
2. An additional monitoring well should be installed between the source area of contamination and the Base Well 11. Ground water from this well should be analyzed for base/neutral extractable organics and purgeable organics and priority pollutant metals.
3. A series of soil samples should be obtained from the area of suspected contamination, around the NW-SE Instrument Runway, if additional sampling and analysis confirms contaminant migration toward Base Well 11. Soil samples should be analyzed for purgeable organics, priority pollutant metals, and base/neutral extractable organics.
4. An endangerment assessment should be performed to evaluate the threat to potential receptors based on the additional information obtained from recommended sampling.
5. If warranted, corrective measures should be developed based on the results of additional studies. Corrective measures might include source control and control of contaminant migration.

6.6 ZONE 8--AREA "6000" LANDFILL

This zone was utilized for the disposal of old parts, batteries, and empty containers from 1945 to 1965. Low levels of chlorinated solvents, phthalates, and priority pollutant metals were found at this zone. Arsenic was found at concentrations which exceed NPDWR and state MCLs. The surficial aquifer in this zone flows northwest toward East Bay through a wetland marsh area. Since East Bay separates Tyndall AFB from potential off-base wells, and the direction of flow in the Floridan Aquifer is toward the Gulf of Mexico and away from Panama City, there is no likelihood that off-base migration of contaminants will affect ground

water in Panama City. The surficial aquifer is not used as a water supply on Tyndall AFB, with the exception of Base Well 11, which is upgradient and several miles from Zone 8. Therefore, the site does not appear to present an imminent human health hazard from the consumption of contaminated ground water. Due to the aforementioned findings, this zone has been placed in Category II. The following recommendations are made for the future management of this site:

1. A confirmatory round of sampling should be conducted at all existing monitor wells. Samples should be analyzed for purgeable organic compounds, base/neutral organics, and priority pollutant metals.
2. Install an additional monitor well downgradient of T8-4 to determine the downgradient extent of contamination. This well should be sampled for purgeable organics, base/neutral organics, and priority pollutant metals.
3. Soil samples from areas with dissolved soils, stressed vegetation, or that appear potentially contaminated should be collected and analyzed for purgeable organic compounds, base/neutral organics, and priority pollutant metals.
4. Well T8-2, which was damaged by vehicular traffic and no longer usable, should be properly abandoned. The protective steel casing should be removed, and the well should be grouted closed.

6.7 ZONE 9--POL AREA B

This site has been in operation since 1943. Detectable levels of chlorinated solvents, benzene, toluene, ethylbenzene, petroleum hydrocarbons, and metals were found at this site. The concentration of benzene (270 μg/L) present at this zone exceeded NPDWR and state MCLs. There is evidence of POL contamination at Well T9-4, with soils in the area being visibly contaminated. One base supply well (Well 2) is located downgradient in the Floridan Aquifer at a distance of 850 ft from Zone 9. Because East Bay separates Tyndall AFB from potential off-base

wells and, in addition, the direction of flow in the Floridan Aquifer is toward the Gulf of Mexico and away from Panama City, there is no likelihood that off-base migration of contaminants will affect ground water in Panama City. The surficial aquifer is not used as a water supply on Tyndall AFB, with the exception of Base Well 11, which is over 1 mile from Zone 9. Due to the high concentration of benzene and toluene onsite, and the likelihood of an ongoing leak in one of the POL storage tanks, this zone has been assigned to Category III. The following recommendations are made for future management of this site:

1. Evaluate the integrity of existing tanks and integral piping by tank testing methods (i.e., precision and pressure testing).
2. Additional monitor wells should be located onsite to determine the areal extent of contamination. The wells should be sampled for purgeable organics, metals, and petroleum hydrocarbons.
3. It is recommended that a deeper monitor well (~50 to 100 ft, as determined based on subsurface characteristics) be installed adjacent to Well T9-4 to characterize the extent of vertical contamination.
4. All wells should be sampled for purgeable organics, petroleum hydrocarbons, and metals.
5. Delineate source(s) of hydrocarbon contamination using soil gas analysis and soil sampling.
6. Aquifer testing (i.e., slug and pump testing) and ground water modeling should be performed, as appropriate, to determine the pollutant fate and transport.
7. An endangerment assessment should be performed to evaluate the threat to potential receptors based on the information obtained.
8. Potential site remedies should be identified and evaluated, including removal of leaking tank(s) and treatment of ground water by air stripping and activated carbon.

6.8 ZONE 10--"SHELL BANK" FIRE TRAINING AREA

This site was utilized as a fire training area and a main repository for POL waste from 1943 to 1952 and again from 1968 to 1980. Chlorinated solvents, benzene, and lead were detected at Zone 10. The concentration of benzene exceeded NPDWR and state MCLs. Since East Bay separates Tyndall AFB from potential off-base wells and, in addition, the direction of flow in the Floridan Aquifer is toward the Gulf of Mexico and away from Panama City, there is no likelihood that off-base migration of contaminants from Zone 10 will affect ground water in Panama City. Also, the surficial aquifer is not used as a water supply on Tyndall AFB, with the exception of Base Well 11, which is approximately 2 miles from Zone 10. Therefore, the site does not appear to present an imminent human health hazard from the consumption of contaminated ground water. This zone has been assigned to Category II. The following recommendations are made for future management of the site:

1. Well T10-2 should be sampled for volatile organics to evaluate the existance of chlorinated solvents and benzene.
2. Surface water and sediments in Shoal Point Bayou should be obtained and sampled for purgeable organics, and petroleum hydrocarbons. Samples should be obtained from Shoal Point Bayou near Well T10-2.
3. The areal extent of the source of contamination around Well T10-2 should be determined using soil gas and soil sampling techniques.
4. An additional monitor well should be installed near the disturbed area. Ground water samples should be collected from this new well and all existing monitor wells and analyzed for purgeable organics, petroleum hydrocarbons, and metals.
5. If, based on recommendation 3 above, the area around Well T10-2 has significant contamination, monitor wells should be installed in the surficial aquifer to verify the areal and vertical extent of the ground water contamination. These monitor wells should be analyzed for purgeable organics, and petroleum hydrocarbons.

6.9 ZONE 11--ACTIVE FIRE TRAINING AREA

This site has been in operation since 1981. Detectable levels of volatile organics, petroleum hydrocarbons, and lead were detected in ground water samples from this site. In addition, surface water samples from Little Cedar Bayou, adjacent to Zone 11, were found to contain low levels of volatile organic compounds and petroleum hydrocarbons. All contaminant concentrations in ground water samples from Zone 11 were below applicable EPA and State MCLs, with the exception of benzene and lead.

Sediment samples in Little Cedar Bayou were found to contain detectable concentrations of lead and petroleum hydrocarbons. Soil samples from this zone also contained detectable levels of lead and petroleum hydrocarbons in addition to benzene, ethylbenzene, toluene, and xylene.

Since East Bay separates Tyndall AFB from potential off-base wells and, in addition, the direction of flow in the Floridan Aquifer is toward the Gulf of Mexico and away from Panama City, there is no likelihood that off-base migration of contaminants will affect ground water in Panama City. Also, the surficial aquifer is not used as a water supply on Tyndall AFB, with the exception of Base Well 11, which is crossgradient and approximately 1 mile from Zone 11. This site, therefore, does not appear to present an imminent human health hazard from the consumption of contaminated ground water. As a result, this zone has been assigned to Category II. The following recommendations are made for future management of this site:

1. A confirmatory round of sampling of existing monitor wells and surface water is recommended. These samples should be analyzed for purgeable organics, petroleum hydrocarbons, and metals.
2. Identify the extent of soil contamination around the existing fuel storage tank using soil gas and soil sampling techniques.
3. Identify the source of contamination upgradient of Well T11-3, using soil gas and soil sampling techniques.

4. Install monitor wells downgradient of the aboveground fuel storage tank and in the vicinity of the oil/water separator based on results of the soil gas survey. Additional monitor wells should be sampled for purgeable organics, petroleum hydrocarbons, and metals. The additional monitor wells will provide information on the areal extent of ground water contamination in the surficial aquifer.
5. Take measures to abate future POL related contamination at this site.

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